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MILAN S. DIMITRIJEVIĆ

LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA AND SERBIA IV (1993 – 1997)

(Bibliography and citation index)

ИСТРАЖИВАЊЕ ОБЛИКА СПЕКТРАЛНИХ ЛИНИЈА У ЈУГОСЛАВИЈИ И СРБИЈИ IV (1993 – 1997)

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CONTENTS-SADRŽAJ

SUMMARY: First part of the publication contains review and analysis of the results of spectral line shapes investigations in Yugoslavia and Serbia for 1993-1997. In the second part, the bibliography of the contributions of Yugoslav and Sebian scientists for 1993 - 1997 is given, together with the citation index for 1993 - 1997 for articles published 1962 - 1997.

REZIME: U prvom delu publikacije dat je pregled i analiza istraživanja oblika spektralnih linija u Jugoslaviji i Srbiji u periodu 1989-1993 godine. U drugom delu data je bibliografija radova jugoslovenskih i srpskih istraživača za period 1993 - 1997, sa istorijatom uticaja svakog objavljenog dela na savremenu nauku, što je urađeno navođenjem izvora u kojima su objavljeni članci citirani. Ovakav indeks citata za period 1993 - 1997, dat je i za sve bibliografske jedinice iz perioda 1962 - 1997

I. SPECTRAL LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA AND SERBIA 1993-1997

Three previously published Bibliographies with citation index on Spectral Line Shapes Investigations in Yugoslavia, cover the period 1962 - 1993 (Dimitrijević, 1990, 1991, 1994). From the September of 1993 up to the March of 1997, 261 articles concerning line shapes investigations have been published by Yugoslav (Serbian) authors. In Serbia have been defended as well 2 Ph. D. and 9 M. Sc. Theses. Consequently, since the first article on this topic (Vujnović et al., 1962) up to the March 1997, 1129 (926 by serbian authors) bibliographic items have been published by 146 Yugoslav authors(119 from Serbia, 26 from Croatia and 1 living in France).

In the considered period various problems have been investigated. Stark broadening of hydrogen and hydrogen-like emitter lines, has been studied in particularly for He II line shapes (924, 1007), and hydrogen line shift due to magnetization of moving plazma (918, 1040). Also, the attention has been paid to the study of H beta line shapes in the presence of a D.C.magnetic field (996, 1083-1085), to the investigation of hydrogen line shapes in a plane - cathode abnormal glow discharge (926, 1128, 1038), radio - frequency discharges (1029) and other discharges (874, 875, 1113, 1114, 1119-1121), the boundary layer influence on low n Balmer lines (1036) and to the influence of ion dynamics (1034).

Work on the experimental determination of Stark broadening parameters of nonhydrogenic atoms and ions has been continued during the considered period: Stark broadening of folowing atoms and ions has been investigated: Ar I (869, 932, 947, 994, 1033, 1082, 1087, 1088), Ar III (993, 1076, 1118), Cd II (994, 1019), Cu I (1031), F V (959), Fe I (1032), He I (885, 1094, 1095), Hg I (873), Na I (873, 950, 961, 1116), N II (945, 946, 1097), N III (958, 1018, 1097), N IV (1097, 1098), Ni I, II (917, 1032, 1091, 1099, 1117), O III (1081), O IV (889, 890, 923, 956, 957, 958, 960, 1006), S III (974, 1049), Si I (873, 1091, 1099). Also, the influence of ion dynamics (927-931, 1009-1013, 1015-1017, 1030, 1092, 1093, 1096), temperature dependence (889, 923, 956, 1006, 1082, 1087), departure from LS coupling (890) and Li- (1042, 1045), Be- (1043, 1045), and B-isoelectronic sequence (956, 957, 1042, 1044, 1046) have been investigated (1125).

Using the semiclassical perturbation approach (Sahal-Bréchot, 1969a,b), the spectra of following elements have been investigated: Be I (878, 905), Mg I (900, 901, 912, 913, 986, 989, 991, 1052, 1072), Al I (904), Rb I (907-909, 981), Se I (1060, 1069, 1070), Sr I (1056, 1057, 1060, 1062), Ba I (1059, 1071, 1125), Li II (978, 979, 985, 1055), Mg II (980, 988, 1064, 1073, 1127), Fe II (962, 967, 969), Ni II (963, 964, 973), Ba II (1059, 1068, 1125), B III (1058, 1063, 1065, 1126), Be III (1053, 1058, 1065), S III (974, 1049), Al III (879, 895), C IV (880), O IV (902, 977, 984), P IV (1061, 1067), S IV (974, 1049), C V (987, 990, 1051, 1074), O V (902, 976, 977), P V (975, 990, 1052), F VII (877), Ne VIII (897, 903, 911), Na IX (897, 911, 914, 983), Al XI (906, 910, 915, 982) and Si XII (899, 906, 910). The influence of oscillator strength values on Stark broadening parameters has been investigated (981) as well.

When it is not possible to use the semiclassical perturbation approach with the appropriate accuracy due to the lack of reliable atomic data, the modified semiempirical method (Dimitrijević and Konjević, 1980) and other approximate methods have been applied. Such methods have been investigated in (992, 1008, 1037) as well as the case of the complexity of radiator in Refs. (876, 1100, 1020). The modified semiempirical approach has been applied to the lines of Sc II (1102, 1105), Bi II (896), Cd II (882), I II (1101), As II (937, 1101), Zn II (882), Br II (1101), Sb II (936, 1101), Y II (1102, 1105), Zr II (1102, 1105), Kr II (1104), Xe II (938, 1103), Zn III (1107), Ge III (1108), As III (1020), Se III (1020) and Cu IV (895).

A special attention has been paid in a number of papers to the investigation of regularities and systematic trends of Stark broadening parameters (871, 872, 883, 884, 1025-1028, 1078, 1079, 1110). Similarities of Stark broadening parameters within spectral series (943, 1027, 1028) have been investigated as well as systematic trends for the same type of transition within a homologous (871, 872), isonuclear (1078, 1079) and isoelectronic sequence (1077). By using regularities and systematic trends, Stark broadening parameters of the following emitters have been predicted: Mg I, Mg II (1112), N V, O VI, S VI, (944), Fe I, Fe II, Fe III, Fe IV, C IV, Si IV (884), Na IX - Ti XX (1080) and doubly-charged ion off-resonances (1111).

Astronomical aspects of spectral line shapes research were studied in a number of publications, as optical depths of the formation of Fraunhofer lines (999), microturbulent sensitivity of solar spectral lines (1089), Mg II h and k lines in spectra of alpha Orionis (1003), IM Pegasi and HR 7275 (1024), IUE spectra of mu Cephei (920-922, 1004), Fourier analysis of rotationally broadened stellar spectra (1002), and Stark broadening parameters for Solar and stellar plasma research (916) and for hot star spectra investigation (893, 894, 934, 935, 939, 940, 965, 968, 971, 972, 1055). On Astronomical Observatory in Belgrade the Belgrade programme for monitoring of activity - sensitive spectral lines of the Sun as a star, during a 11-years Solar cycle is in the course of realization. In accordance with this programme Solar activity influence on spectral lines, as well as the influence of photospheric parameters on such spectral lines has been investigated in several papers (919, 997, 998, 1123, 1124). Due to need to obtain a better connection between astronomical observations and theoretical interpretations of astrophysical spectra, the radiative transfer investigations have also been carried out (888, 954, 1115). Moreover, the influence of the gravitational field on the shape of spectral lines of Seyfert galaxies and quasars (887, 941, 942, 1023) has been studied as well. The work on the formation of a Data Base for the Active Galactic Nuclei (AGN) spectral lines is also in course (1101, 1022).

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Milan S.Dimitrijević

ISTRAŽIVANJA OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI I SRBIJI 1989 - 1993

Tri prethodno objavljene Bibliografije sa indeksom citata o istraživanjima oblika spektralnih linija u Jugoslaviji, pokrivaju period 1962 - 1993. (Dimitrijević, 1990, 1991, 1994). U periodu od septembra 1993. do marta 1997. godine, objavljen je 261 članak koji se odnosi na istraživanje oblika linija jugoslovenskih (srpskih) autora. U Srbiji su takodje odbranjene i 2 doktorske i 9 magistarskih teza. Shodno tome, od prvog članka u ovoj oblasti (Vujnović i dr., 1962) pa do marta 1997, objavljeno je 1129 (926 od strane srpskih autora) bibliografskih jedinica od ukupno 146 (119 iz Srbije, 26 iz Hrvatske i 1 makedonac koji živi u Francuskoj) jugoslovenskih autora.

U razmatranom periodu istraživani su različiti problemi. Štarkovo širenje linija vodonika i vodoniku sličnih emitera, posebno je proučavano u slučaju He II (924, 1007), kao i u slučaju pomaka vodonikovih linija usled magnetizacije plazme koja se kreće (918, 1040). Pažnja je takodje poklonjena proučavanju oblika H beta linije u prisustvu D.C. magnetnog polja (996, 1083-1085), istraživanju oblika vodoničnih linija u neregularnom tinjavom pražnjenju sa ravnom katodom (926, 1128, 1038), radio-frekventnim (1029) i drugim pražnjenjima (874, 975, 1113, 1114, 1119-1121), uticaju graničnog sloja na Balmerove linije sa niskim n (1036) i uticaju dinamike jona (1034).

Rad na eksperimentalnom odredjivanju parametara Štarkovog širenja linija nevodoničnih emitera nastavljen je u razmatranom periodu. Bilo je istraživano Štarkovo širenje sledećih atoma i jona: Ar I (869, 932, 947, 994, 1033, 1082, 1087, 1088), Ar III (993, 1076, 1118), Cd II (994, 1019), Cu I (1031), F V (959), Fe I (1032), He I (885, 1094, 1095), Hg I (873), Na I (873, 950, 961, 1116), N II (945, 946, 1097), N III (958, 1018, 1097), N IV (1097, 1098), Ni I, II (917, 1032, 1091, 1099, 1117), O III (1081), O IV (889, 890, 923, 956, 957, 958, 960, 1006), S III (974, 1049), Si I (873, 1091, 1099). Istraživan je takodje uticaj dinamike jona (927-931, 1009-1013, 1015-1017, 1030, 1092, 1093, 1096), temperaturska zavisnost (889, 923, 956, 1006, 1082, 1087), odstupanja od LS veze (890), kao i Li- (1042, 1045), Be- (1043, 1045) i B- (956, 957, 1042, 1044, 1046) izoelektronski nizovi (1125).

Koristeći semiklasični perturbacioni prilaz (Sahal-Bréchot, 1969a,b), istraživani su spektri sledećih elemenata: Be I (878, 905), Mg I (900, 901, 912, 913, 986, 989, 991, 1052, 1072), Al I (904), Rb I (907-909, 981), Se I (1060, 1069, 1070), Sr I (1056, 1057, 1060, 1062), Ba I (1059, 1071, 1125), Li II (978, 979, 985, 1055), Mg II (980, 988, 1064, 1073, 1127), Fe II (962, 967, 969), Ni II (963, 964, 973), Ba II (1059, 1068, 1125), B III (1058, 1063, 1065, 1126), Be III (1053, 1058, 1065), S III (974, 1049), Al III (879, 895), C IV (880), O IV (902, 977, 984), P IV (1061, 1067), S IV (974, 1049), C V (987, 990, 1051, 1074), O V (902, 976, 977), P V (975, 990, 1052), F VII (877), Ne VIII (897, 903, 911), Na IX (897, 911, 914, 983), Al XI (906, 910, 915, 982) and Si XII (899, 906, 910). Istraživan je i uticaj vrednosti jačina oscilatora na parametre Štarkovog širenja (981).

Kada nije moguće upotrebiti semiklasičan perturbacioni prilaz sa odgovarjućom tačnošću, pošto nemamo pouzdane atomske podatke, korišćeni su modifikovani semiempirijski metod (Dimitrijević i Konjević, 1980) i drugi približni metodi. Takvi metodi istraživani su u referencama (992, 1008, 1037), kao i slučaj kompleksnosti emitera (876, 1020, 1100). Modifikovani semiempirijski prilaz primenjen je na linije Sc II (1102, 1105), Bi II (896), Cd II (882), I II (1101), As II (937, 1101), Zn II (882), Br II (1101), Sb II (936, 1101), Y II (1102, 1105), Zr II (1102, 1105), Kr II (1104), Xe II (938, 1103), Zn III (1107), Ge III (1108), As III (1020), Se III (1020) i Cu IV (895).

U brojnim radovima su istraživane regularnosti i sistematski trendovi parametara Štarkovog širenja (871, 872, 883, 884, 1025-1028, 1078, 1079, 1110). Istraživane su sličnosti parametara Štarkovog širenja u okviru spektralnih serija (943, 1027, 1028), kao i sistematski trendovi za isti tip prelaza u homolognim (871, 872), izonuklearnim (1078, 1079) i izoelektronskim nizovima (1077). Koristeći regularnosti i sistematske trendove, procenjeni su parametri Štarkovog širenja za sledeće emitere: Mg I, Mg II (1112), N V, O VI, S VI, (944), Fe I, Fe II, Fe III, Fe IV, C IV, Si IV (884), Na IX - Ti XX (1080), kao i za ne rezonantne linije dvostruko naelektrisanih jona (1111).

Astronomski aspekti istraživanja spektralnih linija proučavani su u brojnim prilozima. Istraživane su optičke dubine formiranja Fraunhoferovih linija (999), osetljivost sunčevih spektralnih linija na mikroturbulentnost (1089), Mg II h i k linije u spektrima alpha Orionis (1003), IM Pegasi i HR 7275 (1024), IUE spektri mu Cephei (920-922, 1004), Furijeova analiza rotaciono proširenih linija u zvezdanim spektrima (1002), kao i parametri Štarkovog širenja za istraživanje sunčeve i zvezdane plazme (916), kao i za istraživanje spektara toplih zvezda (893, 894, 934, 935, 939, 940, 965, 968, 971, 972, 1055).

Na Astronomskoj opservatoriji u Beogradu u toku realizacije je Beogradski program po kome se u toku 11 godišnjeg sunčevog ciklusa prate spektralne linije Sunca kao zvezde, koje su osetljive na njegovu aktivnost. U skladu sa ovim programom uticaj sunčeve aktivnosti na parametre spektralnih linija, kao i uticaj fotosferskih parametara na ovakve linije, istraživan je u nekoliko članaka (919, 997, 998, 1123, 1124). Takodje su vršena i istraživanja prenosa zračenja, usled potrebe da se poboljša veza izmedju astronomskih posmatranja i teorijske interpretacije astrofizičkih spektara (888, 954, 1115). Izučavan je i uticaj gravitacionog polja na oblik spektralnih linija Sejfertovih galaksija i kvazara (887, 941, 942, 1023). Takodje je u toku i rad na formiranju baze podataka o spektralnim linijama jezgara aktivnih galaksija (AGN) (1101, 1022).

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II. BIBLIOGRAPHY AND CITATION INDEX
BIBLIOGRAFIJA I INDEKS CITATA

INTRODUCTION

The bibliography with the citation index is divided in four parts. In the first, second and third part are given the citation index of articles from 1962-1985, 1985-1989 and 1989 - 1993 period respectively, given in Dimitrijević (1990, 1991, 1994), with the same numeration. Moreover, the number in brackets after the number of an article, if exists, denotes that at least one author is from Serbia. In such a manner the corresponding bibliography for Serbia is included as well. In the fourth part is the bibliography of articles up to the March of 1997 (1993-1997 period and the bibliographical items not included in Dimitrijević 1990, 1991, 1994) and the corresponding citation index. Besides the included citations, papers of Yugoslav scientists are cited in bibliographical reviews: Dimitrijević (1996, 1997), and Dimitrijević and Popović (1996). After each paper of Yugoslav authors, data on articles where the considered paper is cited are given. For citations already existing in the bibliography of Yugoslav authors, only short data are given.

UVOD

Bibliografija sa indeksom citata podeljena je u četiri dela. U prvom, drugom i trećem delu dat je indeks citata članaka iz perioda 1962-1985, 1985-1989 i 1989-1993 respektivno, koji su ušli u prethodne preglede (Dimitrijević, 1990, 1991, 1994), sa istom numeracijom. Osim toga, broj u zagradi iza rednog broja članka ako postoji, označava da je najmanje jedan autor iz Srbije. Na taj način prisutna je i odgovarajuća bibliografija za Srbiju. U četvrtom delu je bibiliografija članaka do marta 1997 (period 1993-1997 i bibliografske jedinice koje nisu uključene u prethodne preglede (Dimitrijević, 1990, 1991, 1994)) i odgovarajući indeks citata. Osim uključenih citata, članci Jugoslovenskih autora su u velikom broju citirani u bibliografskim pregledima: Dimitrijević (1996, 1997) i Dimitrijević i Popović (1996). Posle svakog članka Jugoslovenskih autora, dati su podaci o člancima gde je razmatrani članak citiran. Za članke koji već postoje u bibliografiji jugoslovenskih autora, dati su samo skraćeni podaci.

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Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Acinger, K.:	1970	1972	3
Arsenijević, J.:	1987	1993	6
Atanacković-Vukmanović, O.:	1985	1996	27
Azinović, D.:	1989	1990	2
Beuc, R.:	1980	1989	23
Bajin, I.:	1993	1993	1
Bajović, S. V.:	1993	1993	1
Banjac, O.:	1995	1995	1
Blagojević, B.:	1994	1997	14
Bojović, V.:	1971	1971	1
Bosanac, S.:	1982	1987	4
Božin, J.:	1992	1992	1
Brnović, M. J.:	1992	1992	2
Bukvić, S.:	1992	1996	12
Bzenić, S.:	1990	1992	3
Cekić, M.:	1983	1984	4
Čelebonović, V.:	1982	1982	1
Čerić, V.:	1974	1974	2
Ćirković, Lj.:	1968	1987	38
Ćuk, M.:	1980	1996	35
Cupać, S.:	1991	1991	1
Dimitrijević, M. S.:	1974	1997	378
Djeniže, S.:	1973	1996	87
Djurašević, G.:	1995	1995	2
Djurić, Z.:	1988	1994	5
Djurović, S.:	1975	1997	46
Džimberg-Malčić, V.:	1981	1990	3
Erkapić, S.:	1989	1996	13
Fijan, D.:	1987	1989	8
Francuski, T.:	1989	1989	1
Glavonjić, V.:	1978	1981	6
Gnjatović, S.:	1991	1991	1
Grubor, D. P.:	1973	1981	3

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Grujić, P.:	1970	1996	14
Hadžiomerspahić, D.:	1972	1973	3
Henč-Bartolić, V.:	1988	1990	2
Istrefi, L.:	1981	1991	6
Ivković, M.:	1993	1996	10
Jankov, S.:	1985	1995	7
Jelenković, B.:	1990	1992	4
Jevremović, D.:	1993	1995	8
Jovičić, Z.:	1991	1991	1
Kajzer, M.:	1978	1978	1
Karabin, M.:	1987	1992	3
Kljajić, S.:	1989	1989	1
Knežević, V.:	1978	1978	1
Kobilarov, R.:	1982	1997	46
Koković, M.:	1975	1975	1
Koledin, D.:	1979	1979	1
Konjević, N.:	1969	1997	188
Konjević, R.:	1985	1995	13
Kostić, B.:	1977	1977	1
Kovačević, A.;	1996	1996	1
Kršljanin, V.:	1984	1993	45
Kubičela, A.:	1986	1996	16
Kuraica, M.:	1990	1996	10
Labat, J. M.:	1968	1996	76
Labat, O.:	1980	1991	10
Lakićević, I. S.:	1973	1985	57
Logožar, R.:	1988	1988	2
Lokner, V.:	1980	1983	2
Malešević, M. M.:	1988	1988	1
Malešević, Z.:	1989	1989	1
Manola, S.:	1982	1989	6
Marić, Z.:	1976	1976	1
Marinković, M.:	1991	1991	1
Marinković, M. D.:	1964	1964	1

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Marković-Kršljanin, S.:	1990	1991	2
Mendaš, I.:	1993	1993	1
Mićunović, J.:	1974	1974	1
Mihajlov, A. A.:	1983	1994	11
Mijatović, Z.:	1987	1997	45
Mijović, S.:	1986	1988	3
Miler, D.:	1970	1973	3
Miljević, V.:	1995	1997	2
Milosavljević, M.:	1987	1996	7
Milosavljević, V.:	1994	1996	3
Milošević, S.:	1981	1990	32
Milošević, Z.:	1976	1976	1
Mišković, A.:	1994	1994	1
Mitrović, V.:	1970	1971	2
Milovanov T.:	1995	1995	1
Modrič, D.:	1986	1990	8
Movre, M.:	1976	1990	44
Nikolić, B.:	1991	1995	2
Nikolić, D.:	1993	1994	2
Palle, M.:	1986	1986	1
Panić, K.:	1980	1980	1
Panić, Z.:	1991	1991	1
Pantelić, D.:	1989	1989	1
Pavlov, M.:	1968	1996	30
Paunović, D. R.:	1990	1990	1
Pavlović, M. S.:	1991	1991	1
Pavlović, N. Z.:	1991	1991	1
Petrović, Z. Lj.:	1990	1992	3
Pichler, G.:	1970	1991	113
Pivalica, S.:	1991	1993	3
Platiša, M.:	1970	1996	65
Popović, L. Č.:	1991	1996	45
Popović, M. M.:	1973	1992	11
Popović, M. V.:	1972	1997	33

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Popović, S.:	1975	1975	1
Pružljanin, G.:	1993	1993	1
Purić, J. M.:	1968	1996	136
Racković, I.:	1990	1990	1
Radivojević, D.:	1970	1971	2
Radovanov, S.:	1990	1995	3
Radujkov, V.:	1975	1986	4
Rathore, B.:	1982	1987	16
Rukavina, J.:	1980	1980	1
Ruždjak, V.:	1974	1987	8
Savić, I.:	1995	1996	6
Šćepanović, M.:	1994	1994	2
Šišović, N.:	1995	1996	2
Škovrlj, Lj. .	1978	1991	3
Skuljan, J.:	1990	1996	6
Skuljan, Lj.:	1993	1995	9
Sotirovski, P.:	1987	1992	2
Spasojević, Dj.:	1994	1994	1
Srećković, A.:	1986	1996	68
Stanković, D.:	1990	1990	1
Stanković, N.:	1991	1991	1
Stefanović, I. M.:	1990	1995	8
Stevan ov, M.:	1996	1996	2
Šternberg, Z. W.:	1978	1978	1
Stojanović, V.:	1992	1992	1
Stokić, Z.:	1992	1992	1
Sušić, R.:	1973	1973	1
Terzić, M.:	1975	1987	5
Urošević, V.:	1973	1973	1
Todorović-Vasović, K. N.:	1991	1995	4
Tonejc, A.:	1970	1972	5
Uzelac, N. I.:	1985	1993	17
Vadla, Č.:	1972	1986	19
Velikić, Z. B.:	1991	1991	1

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
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Videnović, I.:	1995	1996	6
Vince, I.:	1983	1996	50
Vrhovac, S.:	1991	1992	2
Vujičić, B. T.:	1982	1996	27
Vujković-Cvijin, P.:	1993	1993	1
Vujnović, V.:	1962	1991	19
Vujović, O.:	1974	1974	1
Vukičević, D.:	1983	1985	3
Zumbulović, Lj.:	1994	1994	1

III. 3. Index of Yugoslav authors and their coauthors

Indeks Jugoslovenskih autora i njihovih koautora

III. 4. Abreviations - Skraćenice

AIAAJ - American Institute of Aeronautics and Astronautics Journal

AIP - American institute of Physics

Ann. Phys. Suppl. - Annales de Physique Supplement

CCP/7 - Collaborative Computational Project No 7

CDS - Centre des Donees Stelaires

C. R. H. Acad. Sci. - Comptes Rendus Hebdomadaires de l'Academie des Sciences

DIAM - Dynamique des Ions, Atomes et Molecules

ECAMP - European Conference on Atomic and Molecular Physics

ECAP - European Conference on Atomic Physics

ECR - Electron Cyclotron Resonance

EGAS - European Group for Atomic Spectroscopy

ERAM - European Regional Astronomy Meeting

ERMA - European Regional Meeting on Astronomy

ESCAMPIG - European Study Conference on Atomic and Molecular Physics of Ionized Gases

ETF - Elektrotehnički fakultet

IAU - International Astronomical Union

ICPIG - International Conference on the Physics of Ionized Gases

ICSLS - International Conference on Spectral Line Shapes

IVTAN - Institut Vysokikh Temperatur Akademii Nauk

JETP - Journal of Experimental and Theoretical Physics

JQSRT - Journal of Quantitiative Spectroscopy and Radiative Transfer

LGU - Leningradskij Gosudarstvenij Universitet

(Kongres) MFAJ - (Kongres) Matematičara fizičara i astronoma Jugoslavije

NBS - National Bureau of Standards

NIST - National Institute of Standards and Technology

PMF - Prirodno-matematički fakultet

Sing. J. Phys. - Singaporean Journal of Physics

SPIG - Symposium on the Physics of the Ionized Gases

Z. Naturforsch. - Zeitschrift für Naturforschung

Z. Physik - Zeitschrift für Physik

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STATISTICAL INVESTIGATION OF THE RELATION BETWEEN THE MASS RATIO AND THE DYNAMICAL ORBITAL ELEMENTS e, P, a OF THE VISUAL BINARIES

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LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA II (1985–1989)

(Bibliography and Citation Index)

ISTRAŽIVANJE OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI II (1985–1989)

(Bibliografija i indeks citata)

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CONTENTS — SADRŽAJ

SUMMARY: First part of the publication contains review and analysis of the results of spectral line shapes investigations in Yugoslavia in the period 1985–1989. In the second part, the bibliography of the contributions of Yugoslav scientists is given, together with the citation index.

REZIME: U prvom delu publikacije dat je pregled i analiza istraživanja oblika spektralnih linija u Jugoslaviji u periodu 1985–1989 godine. U drugom delu data je bibliografija radova jugoslovenskih istraživača, sa istorijatom uticaja svakog objavljenog dela na savremenu nauku, što je urađeno navođenjem izvora u kojima su objavljeni članci citirani.

I. SPECTRAL LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA 1985–1989

The recently published Bibliography and citation index on Spectral Line Shapes Investigations in Yugoslavia, covers the period 1962 - August 1985 (Dimitrijević, 1990). In the period September 1985 – December 1989, 242 articles concerning line shapes investigations have been published by Yugoslav authors (as compared to 371 in the period 1962 - Agust 1985), as well as 4 Ph. D. and 3 M. Sc. Theses. Consequently, since the first article on this topic (Vujnović et al, 1962) up to the end of 1989, 613 bibliographic items have been published by 89 Yugoslav authors. The number of published articles, authors, B. Sc., M. Sc., and Ph. D. theses are given in Table 1 for each year.

Research on Spectral Line Shapes in Yugoslavia, is developed in several institutions and cities as Institute of Physics in Zemun, Faculty of Physics and Astronomical Observatory (Belgrade), Institute of Physics of the University (Zagreb) and Faculty of Sciences (Novi Sad).

In the considered period various problems have been investigated. Stark broadening of hydrogen and hydrogen-like emitter lines, has been investigated in particularly for H-beta line dip-, and peaks-shift, central structure and profiles (426, 427, 483, 527, 587); He II Balmer beta line widths (599), and He II P-alpha line plasma shifts (532). Also, the attention is paid to the influence of the glass-to-plasma boundary layers in T-tube hydrogen plasmas on line intensities (429), profiles (483) and line to continuum intensity ratios (428), and, to the transition of hydrogen line spectrum in continuum (502).

A lot of work has been done also on the experimental determination of Stark broadening parameters of nonhydrogenic atoms and ions: Stark broadening of folowing atoms and ions has been investigated:

Ar I, II, III, IV (411, 431, 472, 545, 581, 606); Br I, II (521, 524, 526, 582); C II, III, IV (407, 522, 530); Cl I, II, III, IV (405, 493, 524, 525, 551, 582); F I, III (524, 525, 582); HeI (383, 436, 444, 445, 531, 560, 586, 588, 607, 612); I I(523, 524, 582); Kr I, II, III (411, 431, 472, 555, 606, 608); Ne I, II, III, IV (411, 431, 434, 435, 472, 487, 489, 490, 545, 550, 606); N II, III, IV, V (432, 492, 530, 547); O III, IV, V (491, 547, 548); Si II (598); Xe II, III (411, 431, 472, 606), Zn I (380). Also, the influence of ion dynamics has been investigated (471, 588, 531). In order to illustrate the contribution of Yugoslav scientists, in Table 2 is presented the number of references concerning experimentally determined Stark broadening parameters from Yugoslav authors and from others, cited in the review of Konjević and Wiese (1990) covering the period from 1982 year. One can see that an especially significant contribution exists in the case of multiply charged ions.

Theoretical investigations of non hydrogenic emitter Stark broadening were developed in several directions. An especial effort has been done in order to develop and test the modified semiempirical method (Dimitrijević and Konjević, 1980). This method, originally developed for the ion line widths, has been extended to the Stark shifts also (396, 397, 398, 460, 461, 462, 569, 592), and a simple formula useful especially in astrophysics has been derrived (459). Moreover, a simple semiclassical method for evaluation of Stark broadening parameters of neutral atom lines has been developed (393, 394, 395). An effort has been done also to develop a method for simple estimates of Stark widths along a homologous sequence (400, 573, 574, 575) and a method useful especially in astrophysics, based on the systematic dependence on the ionization potential (488, 514, 518). Approximate methods have been used and tested on numerous examples (409, 410, 414, 475, 507, 508, 509, 559, 591, 593, 594, 595, 596, 597).

Using the semiclassical perturbation approach (Sahal-Bréchot, 1969a,b), the spectra of following elements have been investigated: Ga II, III (392), Cu I (581, 614), Cu IV (512, 571), Ar II (403, 404), C IV (465, 467, 511, 515, 576), K I (466, 468), Si II (478, 534), Si IV (519, 579), Li-like ions (578). The influence of the perturber path deflection from straight line, due to the back reaction of neutral emitter on Stark broadening and collision phase shifts, has been investigated (406, 569) as well as plasma screening effects on Stark broadening at the adiabatic limit (513, 570, 572) and the influence of resonance structures in electron scattering cross sections on Stark broadening (392).

A special attention has been paid in a number of papers to the investigation of regularities and systematic trends of Stark broadening parameters (389, 400, 401, 402, 403, 404, 411, 431, 433, 463, 466, 468, 472, 488, 492, 501, 519, 520, 524, 544, 545, 546, 547, 548, 551, 559, 566, 605). Similarities of Stark broadening parameters within the same multiplets (403, 404), supermultiplet (403, 404), transition array (389) and spectral series (401, 402, 466, 468, 519) have been examinated. Also, systematic trends for the same type of transition within a homologous and isoelectronic sequence (549) as well as the dependence of Stark broadening parameters on the ionization potential and on the element ordinal number, giving as the result simple formulae of astrophysical importance (520, 544, 545, 547, 548, 551). An investigation on similarities and regularities for line broadening due to collisions with neutral perturber has also been carried out with the special intention to improve the Van der Waals formula (464, 514, 516).

Astronomical apsects of spectral line shapes research were also investigated, as the limb effect, shapes and asymmetries and bisectors of solar spectral lines (382, 415, 416, 442, 443, 477, 498, 499, 500, 611), Na abundance in Solar atmosphere (379), spectral analysis of a white light flare (494), Be stras spectra (447, 504), mechanisms of neutral oxygen line formation in stellar shels (456, 457, 458), development and weakening of shell spectrum of 88 Herculis, (528), Fe II lines in the spectrum of Am 15 Vulpeculae (300), and, Stark shifts in spectra of hot DA white dwarfs (413, 533), microturbulence and spectral line shapes (378), and Lyman alpha line transfer in chromospheric conditions (450). On Astronomical Observatory in Belgrade the Belgrade programme for monitoring of activity — sensitive spectral lines of the Sun as a star, during a 11-years Solar cycle is in the course of realization (446, 559).

In order to obtain a better connection between astronomical observations and theoretical interpretations of astrophysical spectra, the radiative transfer investigations have also been carried out (376, 384, 385, 386, 448, 449, 451, 452, 553, 561).

In a number of papers, satellite and diffuse bands of NaCd (539, 543, 562, 604), KHg (540), NaHg(562), and TlHg(541) excimers have been studied as well as the spectrum and the photochemical production of NaCd (529, 584, 585), LiMg (542) and metal vapor (486) excimers. Continua, satellite and diffuse bands have been studied also (422, 424, 482, 485, 505, 564, 565), particularly on the case of alkali vapors (381, 387, 412, 418, 430, 437, 439, 453, 473, 474, 479, 503, 538, 600, 601, 602, 603). Moreover, ionization of lithium vapor by CW quasiresonant laser radiation (438, 496), fluorescence in dimers and diatomic molecules (417, 419, 420), laser induced chemiluminescence (555), collisional population of K_2 atomic states (589), spectroscopy of collisional and radiative processes of importance for the interpretation of spectra of diatomic molecules (388, 425, 480, 484, 495, 506, 552, 609), intermediate and long range interaction potentials of heteronuclear and homonuclear alkali dimers and quasimolecules (421, 423, 481, 503, 536, 552) and interaction potentials, oscillator strengths, and quasistatic line shapes for Eu-Sr quasimolecule, have been investigated.

The contribution and influence of Yugoslav scientists in the international effort on investigation and interpretation of line shapes is well illustrated by the bibliography and citation index presented in the second part.

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TABLES — TABELE

Table 1. Number of articles, authors, B. Sc., M. Sc., and Ph. D. theses in the period 1962–1989.

Broj radova, autora, diplomskih, i magistarskih radova i doktorskih disertacija u periodu 1962–1989.

Year godina	No. of publications Br. članaka	No. of authors Br. autora	B. Sc Dipl.	M. Sc. Mag.	Ph. D Dokt.
1962	1	1			
1963	0				
1964	2	2			
1965	1	1			
1966	0				
1967	0				
1968	2	4			
1969	4	4		1	
1970	15	13			
1971	11	9	1	2	
1972	10	11			1
1973	10	13	2	1	
1974	16	16	1		1
1975	14	15	2	1	
1976	23	16	1	1	
1977	13	14	1	1	1
1978	23	16		1	1
1979	17	14		1	
1980	30	19	1		
1981	26	17	1		1
1982	46	19	1		2
1983	32	20		1	
1984	44	22		1	1
1985	43	23		1	1
1986	62	33	3	1	
1987	58	33			
1988	65	34			
1989	55	34		3	
Total Ukupno	613				

Table 2. The number of references concerning experimentally determined Stark broadening parameters from Yugoslav authors and from others, cited in (Konjević, Wiese, 1990)

Broj referenci u kojima se daju eksperimentalni podaci za parametre Štarkovog širenja, od Jugoslovenskih i drugih autora, a koje su citirane u pregledu Konjevića i Wiese-a (1990).

Element Element	Yugoslav authors Jugoslovenski autori	Others Ostali
Neutrals — Neutrali		
Al I	–	2
Ar I	1	7
Br I	1	–
C I	–	3
Cl I	1	1
Co I	1	–
Cs I	2	1
Cu I	1	2
F I	2	1
Fe I	–	1
Ga I	–	1
Ge I	–	1
He I	1	1
Hg I	–	1
In I	–	1
K I	–	1
Kr I	–	1
Ne I	2	1
O I	–	2
P I	–	1
S I	–	2
Xe I	–	1
Singly charged ions – Jednostruko naelektrisani joni		
Al II	2	–
Ar II	1	4
Bi II	1	–
Br II	1	–
C II	1	2
Ca II	–	1
Cl II	1	–
Cr II	1	–
Cu II	–	2
Ga II	–	1

(continuation)

Element Element	Yugoslav authors Jugoslovenski autori	Others Ostali
In II	–	1
Kr II	2	1
N II	2	1
Ne II	3	–
O II	1	–
P II	1	1
Pb II	1	–
S II	–	2
Sb II	1	–
Si II	1	1
Sn II	1	–
Xe II	3	2
Doubly charged ions – Dvostruko naelektrisani joni		
Ar III	2	–
C III	1	1
Cl III	1	–
F III	1	–
Kr III	1	–
N III	1	1
Ne III	2	–
O III	1	–
Si III	–	1
Xe III	1	–
Triply charged ions – Trostruko naelektrisani joni		
AR IV	1	–
C IV	1	4
Cl IV	1	–
N IV	1	–
Ne IV	1	–
O IV	1	–
Other ions – Ostali joni		
N V	1	2
O V	1	–
O VI	–	1

ISTRAŽIVANJA OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI 1985–1989

Nedavno objavljena Bibliografija i indeks citata o istraživanjima oblika spektralnih linija u Jugoslaviji, pokriva period od 1962. do avgusta 1985. (Dimitrijević, 1990). U periodu od septembra 1985. do decembra 1989. godine, objavljena su 242 članka koji se odnose na istraživanje oblika linija (u poređenju sa 371 člankom jugoslovenskih autora u periodu 1962. – avgusta 1985), kao i 4 doktorske i 3 magistarske teze. Shodno tome, od prvog članka u ovoj oblasti (Vujnović et al., 1962) pa do kraja 1989, objavljeno je 613 bibliografskih jedinica od ukupno 89 jugoslovenskih autora. Broj objavljenih članaka, autora, diplomskih radova, magistarskih i doktorskih teza dat je za svaku godinu u Tabeli 1.

Istraživanje oblika spektralnih linija u Jugoslaviji odvija se u nekoliko institucija i gradova i to u Institutu za fiziku u Zemunu, Fakultetu za fiziku i Astronomskoj opservatoriji (Beograd), Institutu za fiziku Sveučilišta (Zagreb) i Prirodno-matematičkom fakultetu (Novi Sad).

U razmatranom periodu istraživani su različiti problemi. Štarkovo širenje linija vodonika i vodoniku sličnih jona, ispitivano je na primeru centralnog udubljenja, pomaka pikova, centralne strukture i profila H-beta linije (426, 427, 483, 527, 587); širine Balmer-beta linije He II (599), i plazmenog pomaka linije He II P-alfa (532). pažnja je takođe posvećena: istraživanju uticaja graničnog sloja između stakla i plazme u vodoničnoj plazmi T-cevi na intenzitete linija (429); profilima (483); odnosu intenziteta linije i kontinuuma (428); i, prelazu vodoničnog linijskog spektra u kontinuum (502).

Veliki je trud uložen i u eksperimentalno određivanje parametara Štarkovog širenja nevodoničnih atoma i jona. Bilo je istraživano Štarkovo širenje sledećih atoma i jona: Ar I, II, III, IV (411, 431, 472, 545, 581, 606); Br I, II (521, 524, 526, 582); C II, III, IV (407, 522, 530), Cl I, II, III, IV (405, 493, 524, 525, 551, 582); F I, III (524, 525, 582); He I (383, 436, 444, 445, 531, 560, 586, 588, 607, 612); I I (523, 524, 582); Kr I, II, III (411, 431, 472, 555, 606, 608); Ne I, II, III, IV (411, 431, 434, 435, 472, 487, 489, 490, 545, 550, 606); N II, III, IV, V (432, 492, 530, 547); O III, IV, V (491, 547, 548); Si II (598); Xe II, III (411, 431, 472, 606); Zn I (380). Takođe, bio je istraživan i uticaj dinamike jona (471, 588, 531). Da bi se ilustrovao doprinos jugoslovenskih naučnika, u Tabeli 2 je predstavljen broj referenci koje se odnose na eksperimentalno određivanje parametara Štarkovog širenja, kako jugoslovenskih autora, tako i ostalih, koji su citirani u pregledu Konjevića i Wiese-a (1990) i koji pokriva period od 1982. godine. Može se videti da posebno značajan doprinos postoji u slučaju višestruko naelektrisanih jona.

Teorijska istraživanja Štarkovog širenja nevodoničnih emitera, razvijala su se u više pravaca. Poseban napor je učinjen da se razvije i testira modifikovani semiempirijski metod (Dimitrijević i Konjević, 1980). Ovaj metod, koji je u originalnom obliku razvijen za širine jonskih linija, proširen je na Štarkove pomake (396, 397, 398, 460, 461, 462, 569, 592), a na osnovu njega je izvedena jednostavna formula, koja je posebno korisna u astrofizici (459). Osim toga, razvijen je i jednostavan semiklasični metod za procenu parametara Štarkovog širenja linija neutralnih atoma (393, 394, 395). Radilo se takođe na razvijanju metoda za jednostavnu procenu Štarkovih širina duž niza homolognih emitera (400, 573, 574, 575) i na razvoju metoda zasnovanog na sistematskoj zavisnosti od jonizacionog potencijala (488, 514, 518). Aproksimativni metodi su testirani i korišćeni na brojnim primerima (409, 410, 414, 475, 507, 508, 509, 559, 591, 593, 594, 595, 596, 597).

Koristeći semiklasični perturbacioni prilaz (Sahal-Bréchot, 1969a,b), istraživani su spektri sledećih elemenata: Ga II, III (392), Cu I (581, 614), Cu IV (512, 571), Ar II (403, 404), C IV (465, 467, 511, 515, 576), K I (466, 468), Si II (478, 534), Si IV (519, 579) i litijumu slični joni (578). Istraživan je i uticaj odstupanja putanje perturbera od prave linije, usled povratne reakcije neutralnog emitera, na Štarkovo širenje i fazni pomak (406, 569) kao i uticaj Debajevog ekraniranja na Štarkovo širenje na adijabatskoj granici (513, 570, 572) i uticaj rezonantnih struktura u preseku za rasejanje elektrona, na parametre širenja (392).

U brojnim radovima su istraživane regularnosti i sistematski trendovi parametara Štarkovog širenja (389, 400, 401, 402, 403, 404, 411, 431, 433, 463, 466, 468, 472, 488, 492, 501, 519, 520, 524, 544, 545, 546, 547, 548, 551, 559, 566, 605). Takođe su istraživane sličnosti parametara Štarkovog širenja u okviru istog multipleta (403, 404), supermultipleta (403, 404), skupova prelaza (389) i spektralnih serija (401, 402, 466, 468, 519), kao i sistematski trendovi za isti tip prelaza u homolognim (400, 411, 431, 463, 472, 488, 501, 524, 559) i izoelektronskim nizovima (549) a osim toga i zavisnost parametara širenja od rednog broja elemenata i jonizacionog potencijala, što je kao rezultat dalo proste formule, koje su od interesa za astrofiziku (520, 544, 545, 547, 548, 551). Takođe je izvedeno istraživanje sličnosti i regularnosti u slučaju linija proširenih sudarima sa neutralnim perturberima, sa ciljem da se poboljša Van der Waalsova formula (464, 514, 516).

Pažnja je posvećena i astronomskim aspektima istraživanja spektralnih linija, kao što su limb efekat, profili, asimetrije i bisektori spektralnih linija Sunca (382, 415, 416, 442, 443, 477, 498, 499, 500, 611), zastupljenost Na u Sunčevoj atmosferi (379), spektralna analiza hromosferske erupcije u beloj svetlosti (494), spektri Be zvezda (447, 504), mehanizmi formiranja linija neutralnog vodonika u zvezdanim omotačima (456, 457, 458), razvoj i slabljenje spektra omotača 88 Herculis (528), Fe II linije u spektru Am 15 Vulpeculae (300), Štarkovo širenje u spektrima toplih DA belih patuljaka (413, 533), mikroturbulencija i profili spektralnih linija (378) i prenos Lajman alfa linije u hromosferskim uslovima (450). Na Astronomskoj opservatoriji u Beogradu, u toku je realizacija Beogradskog programa za praćenje spektralnih linija Sunca kao zvezde, u toku 11-togodišnjeg ciklusa njegove aktivnosti (446, 559).

Da bi se uspostavila bolja veza između astronomskih posmatranja i teorijske interpretacije astrofizičkih spektara, vrše se takođe i istraživanja prenosa zračenja (376, 384, 385, 386, 448, 449, 451, 452, 553, 561).

U nizu članaka, izučavani su sateliti i difuzne trake NaCd (539, 543, 562, 604), KHg (540), NaHg(562), i TlHg(541) ekscimera, kao i spektar i fotohemijska produkcija NaCd (529, 584, 585), i LiMg (542) ekscimera, kao i ekscimera u slučaju metalnih para (486). Takođe su proučavani kontinuumi, sateliti i difuzne trake (422, 424, 482, 485, 505, 564, 565), i to naročito u slučaju alkalnih para (381, 387, 412, 418, 430, 437, 439, 453, 473, 474, 479, 503, 538, 600, 601, 602, 603). Osim toga, istraživani su jonizacija pare litijuma kvazirezonantnim CW laserskim zračenjem (438, 496), fluorescencija u dimerima i dvoatomnim molekulima (417, 419, 420), laserski indukovana hemiluminescencija (555), sudarna populacija atomskih stanja K (589), spektroskopija sudarnih i radijativnih procesa od značaja za interpretaciju spektara dvoatomnih molekula (388,425, 480, 484, 495, 506, 552, 609), intermedijarni i dugodometni interakcioni potencijali heteronuklearnih i homonuklearnih alkalnih dimera i kvazimolekula (421, 423, 481, 503, 536, 552), i interakcioni potencijali, jačine oscilatora i kvazistatički profili linija Eu-Sr kvazimolekula.

Uticaj Jugoslovenskih stvaralaca i njihov doprinos međunarodnim naporima na istraživanju i interpretaciji profila spektralnih linija, dobro ilustruje bibliografija sa indeksom citata, koja je data u drugom delu.

II. BIBLIOGRAPHY AND CITATION INDEX
BIBLIOGRAFIJA I INDEKS CITATA

INTRODUCTION

The bibliography with the citation index is divided in two parts. In the first part is given the citation index of articles from 1962–1985 period, given in Dimitrijević (1990), with the same numeration. In the second part is the bibliography of articles up to the end of 1989 (1985–1989 period and the bibliographical items not included in Dimitrijević (1990) and the corresponding citation index. Besides the included citations, papers of Yugoslav scientists are largely cited in the bibliographical reviews: Dimitrijević (1990), Teleki (1987) and Bibliografski zbornik PMF (1990). I tried to see personally each paper included. After each paper of Yugoslav authors, data on articles where the considered paper is cited are given. For citations already existing in the bibliography of Yugoslav authors, only short data are given.

UVOD

Bibliografija sa indeksom citata podeljena je u dva dela. U prvom delu dat je indeks citata članaka iz perioda 1962–1985, koji su ušli u prethodni pregled (Dimitrijević, 1990), sa istom numeracijom. U drugom delu je bibiliografija članaka do kraja 1989 (period 1985–1990 i bibliografske jedinice koje nisu uključene u prethodni pregled (Dimitrijević, 1990)) i odgovarajući indeks citata. Osim uključenih citata, članci Jugoslovenskih autora su u velikom broju citirani u bibliografskim pregledima: Dimitrijević (1990), Teleki (1987) i Bibliografski zbornik PMF (1990). Svaki uključeni članak pokušao sam da vidim lično. Posle svakog članka Jugoslovenskih autora, dati su podaci o člancima gde je razmatrani članak citiran. Za članke koji već postoje u bibliografiji jugoslovenskih autora, dati su samo skraćeni podaci.

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II.1. CITATION INDEX OF ARTICLES FROM 1962–1985 PERIOD

INDEKS CITATA ČLANAKA IZ PERIODA 1962–1985

1962

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III. APPENDIX — PRILOG

III.1. Articles with 20 or more citations
Članci koji su 20 ili više puta citirani

		No. of citations Br. citata
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III.2. Yugoslav scientists — Jugoslovenski istraživači

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Acinger, K.:	1970	1972	3
Arsenijević, J.:	1987	1988	4
Atanacković Vukmanović, O.:	1985	1989	12
Azinović, D.:	1989	1989	1
Beuc, R.:	1980	1989	23
Bojović, V.:	1971	1971	1
Bosanac, S.:	1982	1987	4
Cekić, M.:	1983	1984	2
Čelebonović, V.:	1982	1982	1
Čerić, V.:	1974	1974	2
Ćirković, Lj.:	1968	1987	38
Ćuk, M.:	1980	1989	27
Dimitrijević, M. S.:	1974	1989	169
Djeniže, S.:	1973	1989	33
Djurić, Z.:	1988	1989	3
Djurović, S.:	1975	1989	12
Džimberg, V.:	1981	1981	1
Erkapić, S.:	1989	1989	1
Fijan, D.:	1987	1989	8
Francuski, T.:	1989	1989	1
Glavonjić, V.:	1978	1981	6
Grubor, D	1973	1981	3
Grujić, P.:	1970	1979	11
Hadžiomerspahić, D.:	1972	1973	3
Henč-Bartolić, V.:	1988	1988	1
Istrefi, L.:	1981	1988	5
Jankov, S.:	1985	1987	4
Kajzer, M.:	1978	1978	1
Karabin, M.:	1987	1987	1
Knežević, V.:	1978	1978	1
Kobilarov, R.:	1982	1989	6
Koković, M.:	1975	1975	1
Koledin, D.:	1979	1979	1
Konjević, N.:	1969	1989	119
Konjević, R.:	1985	1988	4
Kostić, B.:	1977	1977	1
Kršljanin, V.:	1984	1989	26
Kubičela, A.:	1986	1988	7
Labat, J. M.:	1968	1989	40
Labat, O.:	1980	1988	6
Lakićević, I. S.:	1973	1985	57
Logožar, R.:	1988	1988	2
Lokner, V.:	1980	1983	2

Malešević, M.:	1989	1989	1
Manola, S.:	1982	1989	6
Marić, Z.:	1976	1976	1
Marinković, M. D.:	1964	1964	1
Mićunović, J.:	1974	1974	1
Mihajlov, A. A.:	1983	1989	1
Mijatović, Z.:	1989	1989	8
Mijović, S.:	1986	1988	3
Miler, D.:	1970	1973	3
Milosavljević, M.:	1987	1989	4
Milošević, S.:	1981	1989	31
Milošević, Z.:	1976	1976	1
Mitrović, V.:	1970	1971	2
Modrić, D.:	1986	1989	6
Movre, M.:	1976	1989	44
Palle, M.:	1986	1986	1
Panić, K.:	1980	1980	1
Pantelić, D.:	1989	1989	1
Pavlov, M.:	1968	1987	10
Pichler, G.:	1970	1989	102
Platiša, M.:	1970	1989	44
Popović, M. M.:	1973	1989	10
Popović, M. V.:	1972	1989	19
Popović, S.:	1975	1975	1
Purić, J. M.:	1968	1989	104
Radivojević, D.:	1970	1971	2
Radujkov, V.:	1975	1986	4
Rathore, B.:	1982	1987	16
Rukavina, J.:	1980	1980	1
Sotirovski, P.:	1987	1987	1
Ruždak, V.:	1974	1987	8
Srećković, A.:	1986	1989	25
Sušić, R.:	1973	1973	1
Škovrlj, Lj.:	1978	1978	2
Šternberg, Z. W.:	1978	1978	1
Terzić, M.:	1975	1987	4
Tonejc, A.:	1970	1972	5
Urošević, V.:	1973	1973	1
Uzelac, N. I.:	1985	1989	6
Vadla, Č	1972	1986	19
Veža, D.:	1978	1989	45
Vince, I.:	1983	1989	25
Vujičić, B. T.:	1982	1989	11
Vujnović, V.:	1962	1989	16
Vujović, O.:	1974	1974	1
Vukičević, D.:	1983	1985	3

III.3. Index of Yugoslav authors and their coauthors
Indeks Jugoslovenskih autora i njihovih koautora

III.4. Abreviations — Skraćenice

AIAAJ — American Institute of Aeronautics and Astronautics Journal

Ann. Phys. Suppl. — Annales de Physique Supplement

C. R. H. Acad. Sci. — Comptes Rendus Hebdomadaires de l'Academie des Sciences

ECAMP — European Conference on Atomic and Molecular Physics

ECAP — European Conference on Atomic Physics

ECR — Electron Cyclotron Resonance

EGAS — European Group for Atomic Spectroscopy

ERMA — European Regional Meeting on Astronomy

ESCAMPIG — European Study Conference on Atomic and Molecular Physics of Ionized Gases

ETF — Elektrotehnički fakultet

IAU — International Astronomical Union

ICPIG — International Conference on the Physics of Ionized Gases

ICSLS — International Conference on Spectral Line Shapes

IVTAN — Institut Vysokikh Temperatur Akademii Nauk

JETP — Journal of Experimental and Theoretical Physics

JQSRT — Journal of Quantitiative Spectroscopy and Radiative Transfer

LGU — Leningradskij Gosudarstvenij Universitet

(Kongres) MFAJ — (Kongres) Matematičara fizičara i astronoma Jugoslavije

NBS — National Bureau of Standards

PMF — Prirodno-matematički fakultet

Sing. J. Phys. — Singaporean Journal of Physics

SPIG — Symposium on the Physics of the Ionized Gases

Z. Naturforsch. — Zeitschrift für Naturforschung

Z. Physik — Zeitschrift für Physik

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MILAN S. DIMITRIJEVIĆ

LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA 1962–1985
(Bibliography and citation index)

ISTRAŽIVANJA OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI 1962–1985
(Bibliografija i indeks citata)

Beograd
1990

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To my parents
SERGIJE and NADA

Roditeljima
SERGIJU i NADI

CONTENTS – SADRŽAJ

SUMMARY: First part of the publication contains review and analysis of the results of spectral line shapes investigations in Yugoslavia in the period 1962–1985, with special emphasis on the importance of such investigations. In the second part, the bibliography of the contributions of Yugoslav scientists is given, togehter with the citation index.

REZIME: U prvom delu publikacije dat je pregled i analiza istraživanja oblika spektralnih linija u Jugoslaviji u periodu 1962–1985. godine, pri čemu je posebna pažnja posvećena značaju ovakvih istraživanja. U drugom delu data je bibliografija radova jugoslovenskih istraživača, sa istorijatom uticaja svakog objavljenog dela na savremenu nauku, što je urađeno navođenjem izvora u kojima su objavljeni članci citirani.

PART I — DEO I

1. SPECTRAL LINE SHAPES INVESTIGATION IN YUGOSLAVIA 1962–1985

As the typical information in astronomy is obtained by analyzing the radiation. The understanding of astrophysical spectral line shapes is of great importance. Spectral line shapes are an important research field, particularly in special laboratories and institutions formed in order to provide basic physical data to astronomers, as e.g. JILA (Joint Institute for Laboratory Astrophysics) in Boulder. Stark and other broadening mechanisms for lines in astrophysical spectra are also investigated within the comission 14 of the IAU for fundamental spectrosopic data.

Typical problems where spectral line shapes investigation is important, may be devided in following groups:

1) Quantitative and qualitative investigation of laboratory and astrophysical plasma spectra;

2) diagnostics of laboratory and astrophysical plasma;

3) research connected with termonuclear fusion and laser produced plasma;

4) determination of chemical abundances in stellar atmospheres using absorption line profiles;

5) investigation of recombination radio line profiles in ionized hydrogen regions as e.g. Orion nebula;

6) radiation transfer through stellar and laboratory plasmas.

Spectral line shapes enter the analysis of a stellar spectrum essentially in two ways:

a) Selected lines from which we may derrive information about stellar parameters require reliable line shape theory and data of high accuracy for the contribution of the main broadening mechanism.

b) For the bulk of ($\geqslant 10^6$) lines, as well as for smaller contributions to the main broadening mechanisms, broadening parameters of only modest accuracy are sufficient. Such lines only add together to the total absorption coefficient, which determines the atmospheric stratification, and we need only the good average accuracy while the accuracy for a particular line is not so important.

Stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters. It is difficult to state in general terms which are the relevant transitions since the atmospheric composition of a star is not known a priori, and many interesting groups of stars exist with very peculiar abundances as compared to the Sun.

The interest for line broadening data is stimulated also by the development of space research. Using space spectroscopy, an extensive amount of spectroscopic information over large spectral region of all kind of celestial objects has been and will be collected, stimulating line shapes research.

*

Since the first article on this topic (Vujnović et al., 1962) up to the august 1985, 371 publications concerning line shapes investigations have been published by 68 yugoslav authors. The number of published articles, authors, B.Sc., M.Sc., and Ph.D. theses are given in Table 1 for every year. One might point out that 113 articles are published in international journals during considered period. Also, 11 B.Sc., 15 M.Sc. and 9 Ph.D. theses have been done. Among the published articles 15 are in Astronomy and Astrophyisics and 1 in Astrophysical Journal.

In published papers, different problems from this research field have been considered. Stark broadening investigation of hydrogen and hydrogen–like emitter lines, has a great practical importance and the corresponding attention has been payd in Yugoslavia to this problem (1, 4, 6, 71, 73, 78, 79, 86, 98, 110, 123, 128, 129, 142, 143, 151, 152, 154, 179, 216). Yugoslav scinetists have experimentally determined Balmer line profiles (1, 4, 73, 151, 152), have studied broadening of the D_β line wings (6) as well as the neutral hydrogen and ionized hydrogen line shifts (129, 154). Particular attention has been payd to the investigation of the ion dynamic influence on the neutral hydrogen line shifts (154). Calculations of hydrogen line shapes were carried out also (143), as well as the study of back reaction influence on hydrogen line far wings (110, 123). Hydrogen spectrum near the ionization limit was investigated also (86, 142, 216).

Influence of typical colder boundary layer in T–tube, on hydrogen plasma spectral line shapes was also examined (78, 79, 98, 179). The results show that line widths are larger when the considered effect is taken into account, and that the influence of the mentioned effect increases if temperature and distance from the line center increase.

Up to date, a large experimental work on Stark broadening for nonhydrogenic emitters has been done in world and Yugoslavia, in laboratory plasmas with $N_e = 2 \times 10^{13} - 4 \times 10^{17} \mathrm{cm}^{-3}$ and $T = 2 \times 10^3 - 6 \times 10^4 \mathrm{K}$. In figures 1–4, the situation according to the critical analysis of experimental data (91, 92, 310, 311) is shown as well as the Yugoslav research workers contribution (papers up to the middle of 1982). In figures are marked only such nonhydrogenic atoms and ions for which reliable experimental data are given in mentioned review articles. With dots are marked elements if only measurements of non Yugoslav authors are given, and with lines if there are only contributions of Yugoslav authors. We see in the figures that Stark broadening parameters are especially known for lighter elements. One can see also that number of data decrease with the increase of ionization degree. In the time of the publication of review articles (310, 311), reliable experimental data for nonhydrogenic ions four and more times charged did not existed.

In table 2 is summarized experimental work of Yugoslav scinetists on nonhydrogenic spectral lines Stark broadening determination up to the middle of 1985. From 1962 up to the august of 1985, Stark widths of 360 lines have been measured for 38 elements of 58 different emitter species, if one takes into account different ionistaion stages also. Stark shift of 187 lines for 31 element and 33 different emitter species have been measured also and a new experimental technique for Stark shift measurement has been developed (44). Results obtained during experimental investigations of nonhydrogenic emitter Stark broadening have been reported in 98 papers.

Theoretical investigations of non hydrogenic emitter Satrk broadening were developed in several directions. In the frame of semiempirical approach, investigations of the applicability of existing theory have been done (14, 15, 27, 127, 150, 166, 167, 169) and new approaches (166, 167, 169, 199, 278, 302, 341) especially convenient for quick calculations of a large number of lines have been developed too. Particularly successful is the modified semiempirical approach (200, 305, 342). Such investigations have been done also in the frame of semiclassical approach (38, 57, 87, 88, 163, 167, 168, 233, 234, 241, 265, 268, 271, 272, 274, 277, 295, 299, 304, 306, 307, 343, 348). The theory for multiply charged ions has been improved (145, 150, 169). Stark broadening parameters for large number of lines of He I (234, 271, 272, 274, 299, 306, 307, 345, 346), Na I (343, 344), K I (347) and other elements, were calculated. The special attention has been payed to the spectral lines of heavy nonhydrogenic neutrals in plasma (232, 268, 297, 304). The work on a new quantum mechanical approach to the Stark broadening of neutral helium started also (149) and the first complete quantum mechanical (strong coupling) calculations for a nonhydrogenic neutral (196, 197) has been carried out. Research on Stark broadening of multiply charged ioons was developed especially intensively. In this research field, the most of experimental (2, 54, 55, 59, 68, 70, 80–84, 94, 102, 116, 117, 135, 158, 205, 312) and theoretical (68, 80, 102, 116, 117, 123, 135, 146, 150, 158, 163–167, 178, 194, 198, 201, 233) results published in the period considered have been obtained by Yugoslav authors. The influence of the perturber path deflection from straight line, due to the back reaction of neutral emitter (88, 89, 110, 123–126, 147, 148, 300, 301) on Stark broadening has been investigated also. Results obtained show that the influence of the effect considered, increases with the decrease of temperature and with the increase of atom polarizability. In order to take into account this effect, corresponding modifications within semiclasiscal (123, 126) and adiabatic (147) theory have been made.

In several papers were investigated non isolated helium lines with forbidden components in laser produced plasma (224, 333, 334, 335, 364, 371), influence of Debye screening (242, 308) influence of different collisional processes on line broadening (231, 267) as well as the yield of resonances (autoionization) to the Satrk Broadening (230, 266).

In large number of papers, regularities and systematic trends of Stark broadening parameters have been studied (53, 69, 104, 105, 108, 109, 113, 137, 138, 145, 153, 155, 159, 160, 165, 170–172, 175, 183–186, 193, 204, 206, 212, 215, 225, 229, 241, 243, 247, 253, 256, 264, 279, 280, 286, 289, 290, 307, 308, 312, 313, 326). Similarities of Stark broadening parameters within the same multiplet and transition array, have been examined. Also, systematic trends for the same type of transitions within a homologous and isoelectronic sequence and within a spectral series, have been studied as well as the dependence of Stark broadening parameters on ionization potential (184, 185, 186, 213, 303, 325, 339, 340), giving as the result simple formulas of astrophysical importance (339, 340, 353, 360, 361). Dependence on element ordinal number has been investigated too (183, 207, 214, 253).

During line shapes studies, attention has been payed and to purely astronomical problems. The influence of rotational motions on spectral line profiles in solar prominences and spiculas (121, 122, 141), Stark broadening of heavy solar ions (195, 226), experimentally measurable consequences of anomalous red shift on the symmetrical spectral line shape (93) and the influence of different line broadening mechanisms on solar limb effect (332, 368, 369, 370) has been studied.

Particularly often are cited and used critical reviews of experimental data for Stark brodening parameters of neutral (91, 310) and ionized (92, 311) emitters. In these reviews, available experimental data are systematized and critically evaluated, which enable their easier application in astronomy and physics research fields.

Complex experimental device with absorption cells and heat–pipe (see fig. 9), for the spectroscopic investigations in emission and absorption, has been developed in the Institute of physics of the University in Zagreb. Using this device, in a series of papers, self broadening in alkali metal vapors (64, 65, 76, 96, 97, 100, 111, 115, 131, 157, 176, 181, 182, 191, 209, 211, 218, 261) and self broadening of Tl 377,6 nm line (132, 133) has been studied. Assymetry of principal series lines of Cs (52, 60, 61, 66, 67, 99, 156) and Rb (156) was particularly investigated, far wings were studied and interaction potential and Van der Waals constant were determined using the principal series of Cs

(62, 63, 77, 130) and Rb (130). Also, peculiar wing assymetry of Li and Na (292) resonance lines has been examined.

In several papers influence on spectral line shapes of emitter (apsorber) non resonant interaction with neutral atoms has been examined. Van der Waals interaction in excited alkali dymers (356) has been studied. Wings (especially their assymetry) of Na lines broadened by collisions with Cs, Rb and K (328, 329), wings of K lines broadened by collisions with Cs (187, 188, 217) and Ar (250), interaction potential between K and Ar (235, 236, 275) and the influence of K–Rb collisions on K lines within impact approximation (260, 291, 297) have been investigated.

Interference and diffuse continua in the Rb_2 spectrum (285, 318, 354); triplet – triplet transitions in dense lithium vapors (330); triplet satellites in the spectrum of alkali homonuclear molecules (316, 367); satellites in alkali metal lines (144, 190, 221, 319); diffuse bands in absorption and emission spectra of dense Li, Li_2, Na, Na_2, K, K_2 and Rb (251, 252, 283, 284, 316, 317, 320, 321, 322, 357, 365) and also tirplet satellite bands in the wings of alkali lines (177, 189, 192, 210, 219, 262, 263, 293, 294, 331) have been studied. Finaly, influence of collisional processes on line shapes connected with redistribution and radiative transfer problem (140, 161, 180, 298) has been examined.

In order to see the contribution of Yugoslav scinetists, one might analyse also Bibliographies on atomic spectral line shapes and shifts for the period 1889–1978 (Fuhr et al. 1972, 1974, 1975, 1978 – complete references are after the introduction in Part II). Among 16 researchers with the largest number of bibliographic unities are 4 Yugoslav scinetists (see Table 3).

2. ISTRAŽIVANJA OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI 1962–1985

S obzirom da se informacije o kosmosu van Sunčevog sistema dobijaju analizom zračenja, proučavanje i analiza astrofizičkih spektara ima veliki značaj. Istraživanje spektralnih linija je od važnosti za istraživačke programe specijalnih laboratorija i institucija osnovanih sa ciljem da obezbede osnovne fizičke podatke astronomima, kao na primer JILA (Joint Institute for Laboraroty Astrophysics) u Boulderu. Proučavanje oblika spektralnih linija je takođe predmet rada komisije 14 za fundamentalne spektroskopske podatke, Međunarodne astronomske unije.

Tipični problemi za koje je važno proučavanje oblika linija mogu se podeliti na sledeće kategorije:

1) kvantitativno i kvalitativno proučavanje spektra iz laboratorijske i astrofizičke plazme;

2) dijagnostika laboratorijske i astrofizičke plazme;

3) istraživanja vezana za termonuklearnu fuziju i laserski proizvedenu plazmu;

4) određivanje zastupljenosti pojedinih elemenata u zvezdanim atmosferama na osnovu profila apsorpcionih linija;

5) ispitivanje profila rekombinacionih radiolinija u oblastima jonizovanog vodonika kao što je maglina u Orionu;

6) proučavanje transfera zračenja kroz stelarnu i laboratorijsku plazmu.

Prilikom analize zvezdanih spektara, podaci o obliku spektralnih linija ulaze u osnovnom na dva načina:

a) Izabrane linije pomoću kojih se mogu dobiti podaci o nekim pojavama i parametrima zvezdanih atmosfera, zahtevaju detaljnu analizu i pouzdanu teoriju oblika spektralnih linija.

b) Za veliki broj linija (10^6), kao i za manje doprinose glavnom mehanizmu širenja linija, dovoljno je poznavati parametre širenja sa manjom tačnošću. Oblici takvih linija zajednički određuju totalni koeficijent apsorpcije, i potrebno je samo poznavanje parametara širenja sa dobrom srednjom tačnošću, dok tačnost pojedinog podatka nije toliko važna.

Za proučavanje zvezdanih spektara potrebno je poznavanje atomskih parametara i parametara širenja spektralnih linija za izuzetno veliki broj prelaza u spektrima različitih atoma i jonizacionih stanja. S obzirom da hemijski sastav zvezdane atmosfere nije poznat a priori, teško je unapred reći koji su nam sve podaci potrebni, a postoji mnogo interesantnih grupa zvezda čiji hemijski sastav znatno odstupa od Sunčevog.

Interes za podatke o oblicima spektralnih linija stimulisan je takođe razvojem kosmičkih istraživanja. Koristeći kosmičku spektroskopiju, prikupljena je i prikuplja se velika količina spektroskopskih informacija u širokom spektralnom području, za kosmičke objekte različite vrste, što posebno podstiče istraživanja oblika spektralnih linija

*

Od prvog članka u ovoj oblasti (1), 68 jugoslovenskih naučnika je objavilo 371 rad o istraživanju oblika spektralnih linija, u periodu do avgusta 1985. godine. Broj publikacija, autora, diplomskih radova, magistarskih i doktorskih disertacija po godini dat je u Tabeli 1. Treba naglasiti da je od 371 objavljenih radova, 113 u međunarodnim časopisima kojih su 15 u Astronomy and Astrophysics a 1 u Astrophysical Journal. U razmatranom periodu odbranjeno je 9 doktorskih i 15 magistarskih teza kao i 11 diplomskih radova.

U objavljenim radovima razmatrani su različiti problemi iz ove oblasti. Proučavanje Štarkovog širenja linija vodonika i vodoniku sličnih emitera ima veliki praktični značaj i kod nas je ovom problemu posvećena odgovarajuća pažnja (1, 4, 6, 71, 73, 78, 79, 86, 98, 110, 123, 128, 129, 142, 143, 151, 152, 154, 179, 216). Naši istraživači su eksperimentalno određivali profile Balmerovih linija (1, 4, 73, 151, 152), istraživali širenje na krilima D_β linije (6) kao i pomak linija neutralnog vodonika i jonizovanog helijuma (129, 154), pri čemu je naročita pažnja posvećena ispitivanju uticaja dinamike jona na pomak linija neutralnog vodonika (154). Takođe su izvedena i izračunavanja profila vodonikovih linija (143), kao i ispitivanje uticaja povratne sprege atoma vodonika koji zrači i perturbujućeg elektrona, na daleka krila vodonikovih linija (110, 123). Vršena su i istraživanja vodonikovog spektra kod granice jonizacije (86, 142, 216).

Ispitivan je takođe uticaj tipičnog hladnijeg graničnog sloja kod vodonične plazme u T cevi, na profile spektralnih linija (78, 79, 98, 179). Rezultati pokazuju da su širine linija veće kada se razmatrani efekat uzme u obzir, kao i da uticaj ovog efekta raste sa povećanjem temperature kao i sa udaljavanjem od centra linije.

Do danas je u svetu i kod nas izvršen obiman eksperimentalni posao na istraživanju Štarkovog širenja linija nevodoničnih emitera, u laboratorijskim plazmama gustine $2 \times 10^{13} - 4 \times 10^{17}$ cm^{-3} i temperature $2 \times 10^3 - 6 \times 10^4$K. Na slikama 1—4 data je analiza postojanja pouzdanih eksperimentalnih podataka u ovoj oblasti prema kritičkoj analizi Konjevića i dr. (91, 92, 310, 311) (Radovi objavljeni do sredine 1982), kao i doprinos naših istraživača. Na šematskim prikazima dela periodnog sistema, naznačeni su samo oni nevodonični atomi i joni, za koje postoje pouzdani eksperimentalni podaci za Štarkove parametre najintenzivnijih linija. Na tačkastoj podlozi dati su elementi za koje su merenja izvršili samo inostrani istraživači dok je pola podloge šrafirano ako postoje podaci i naših autora. Na šrafiranoj podlozi dati su elementi za koje su svi rezultati dobijeni od naših istraživača. Na ovim slikama se vidi, da su Štarkovi parametri naročito dobro poznati kod lakših elemenata. Takođe se vidi da broj dostupnih podataka opada sa porastom stepena jonizacije, te kod atoma koji su jonizovani 4 i više puta, pouzdani eksperimentalni podaci za nevodonične slučajeve u vremenu objavljivanja preglednih članaka (310, 311) nisu postojali.

Eksperimentalni rad naših istraživača na određivanju štarkovih parametara nevodoničnih spektralnih linija do sredine 1985. godine, sumarno je prikazan u Tabeli 2. Od 1962. godine pa do avgusta 1985. godine, izvršen je obiman posao u toku koga su izmerene Štarkove širine 360 linija, za 38 elemenata odnosno 58 različitih vrsta emitera ako uzmemo u ozbir i jonizaciona stanja. Izmereni su takođe i Štarkovi pomaci 187 linija za 31 element odnosno 33 razičitih emitera, pri čemu je razrađena i nova eksperimentalna tehnika za merenje Štarkovih pomaka (44). Rezultati do kojih se došlo u eksperimentalnom ispitivanju Štarkovih parametara nevodoničnih emitera saopšteni su naučnoj javnosti u 98 radova.

Teorijska istraživanja vezana za problematiku Štarkovog širenja nevodoničnih elemenata odvijala su se u više pravaca. U okviru semiempirijskog prilaza problemu, vršena su ispitivanja primenljivosti postojeće teorije (14, 15, 27, 127, 150, 166, 167, 169) a formulisani su i novi prilazi (166, 167, 169, 199, 278, 302, 341) specijalno pogodni za brza proračunavanja velikog broja linija. Naročiti uspeh pokazao je Modifikovani semiempirijski prilaz (200, 305, 342). Ovakva istraživanja vršena su i u okviru semiklasičnog prilaza (36, 67, 87, 88, 163, 167, 168, 233, 234, 241, 265, 268, 271, 272, 274, 277, 295, 299, 304, 306, 307, 343--348) pri čemu je izvršeno poboljšanje teorije za višestrukojonizovane atome (145, 150, 169) i izračunati parametri širenja za veliki broj linija HeI (234, 271, 272, 274, 299, 306, 307, 345, 346), NaI (343, 344), K I (347) i drugih elemenata. Posebna pažnja posvećena je linijama teških nevodoničnih neutrala u plazmi (232, 268, 297, 304). Takođe je započet rad na jednom novom kvantno mehaničkom prilazu širenja linija neutralnog helijuma (149) i izveden prvi potpuni kvantno mehanički proračun za parametre Štarkovog širenja nevodoničnog neutrala (196, 197). Naročito se intenzivno odvijao rad na istraživanju Štarkovog širenja kod višestruko jonizovanih emitera. U ovoj oblasti, većina eksperimentalnih (2, 54, 55, 59, 68, 70, 80–84, 94, 102, 116, 117, 135, 158, 205, 312) i terorijskih (68, 80, 102, 116, 117, 123, 135, 146, 150, 158, 163–167, 178, 194, 198, 201, 233) rezultata objavljenih u razmatranom vremenskom periodu dobijena je u našoj zemlji. Istražen je i uticaj odstupanja putanje perturbera od pravolinijske, usled povratnog dejstva neutralnog emitera (88, 89, 110, 123–126, 147, 148, 300, 301) na Štarkovo širenje spektralnih linija. Rezutati su pokazali da uticaj efekta raste sa smanjenjem temperature i sa povećanjem polarizabilnosti atoma. Da bi se efekat uzeo u obzir, izvršene su odgovarajuće modifikacije u okviru semiklasične (123, 126) i adijabatske teorije (147).

U nekoliko radova istraživane su neizolovane linije helijuma sa zabranjenim komponentama u laserski proizvedenoj plazmi (224, 333, 334, 335, 364, 371), uticaj Debajevog ekraniranja (242, 308), uticaj različitih sudarnih procesa na širenje linija (231, 267) kao i doprinos rezonanci (autojonizacija) Štarkovom širenju (230, 266).

U velikom broju radova proučavane su regularnosti i sistematski trendovi kod Štarkovih parametara spektralnih linija (53, 69, 104, 105, 108, 109, 113, 137, 138, 145, 153, 155, 159, 160, 165, 170–172, 175, 183–186, 193, 204, 206, 212, 215, 225, 229, 241, 243–247, 253, 256, 264, 279, 280, 286, 289, 290, 307, 308, 312, 313, 326). Proučavane su sličnosti kod Štarkovih parametara linija u okviru istog multipleta i grupe supermultipleta. Takođe su proučavani i sistematski trendovi kod Štarkovih parametara za isti tip prelaza u okviru jednog homolognog kao i izoelektronskog niza i spektralnih serija a izučavana je i zavisnost parametara Štarkovog širenja od jonizacionog potencijala (184, 185, 186, 213, 303, 325, 339, 340) što je kao rezultat dalo proste formule od značaja za astrofizička proučavanja (339, 340, 353, 360, 361). Takođe je razmatrana i zavisnost Štarkovih parametara od rednog broja elemenata (183, 207, 214, 253).

Prilikom proučavanja oblika spektralnih linija, pažnja je posvećena i astronomskim problemima. Razmatran je uticaj rotacionih kretanja na profile spektralnih linija u Sunčevim prominencijama i spikulama (121, 122, 141), Štarkovo širenje teških jona na Suncu (195, 226), eksperimentalno merljive posledice anomalnog crvenog pomaka na oblik simetričnih spektralnih linija (93) i uticaj različitih mehanizama širenja spektralnih linija na Limb efekat na Suncu (332, 368–370).

Izuzetno se često pominje i koristi u inostranoj literaturi kritički pregled eksperimentalnih podataka za Štarkove parametre neutralnih (91, 310) i jonizovanih (92, 311) emitera. U ovim pregledima sistematizovani su i kritički procenjeni dostupni eksperimentalni podaci iz razmatrane oblasti, što je omogućilo njihovu širu primenu u nekim oblastima astronomije i fizike.

U Institutu za fiziku sveučilišta u Zagrebu, razviejn je složeni eksperimentalni uređaj sa apsorpcijskim kivetama i toplovodnim pećima (heat–pipe), kombinovanim sa tinjajućim pražnjenjem, za spektroskopska proučavanja u emisiji i apsorpciji (vidi sl. 9). Na njemu je u nizu radova istraživano rezonantno širenje u parama alkalnih metala (64, 65, 76, 96, 97, 100, 111, 115, 131, 157, 176, 181, 182, 191, 209, 211, 218, 261) i rezonantno širenje linije 377,6 nm talijuma (132, 133). Pri tome je posebno proučavana asimetrija linija glavne serije Cs (52, 60, 61, 66, 67, 99, 156) i Rb (156) i ispitivana su daleka krila linija, te određivani potencijal interakcije i Van der Valsova konstanta, pomoću glavne serije Cs (62, 63, 77, 130) i Rb (130). Takođe je istraživana pekulijarna asimetrija krila rezonantnih linija Li i Na (292).

U većem broju radova vršena su istraživanja uticaja nerezonantne interakcije emitera (apsorbera) sa neutralnim atomima na profil spektralne linije. Proučavana je Van der Valsova interakcija u pobuđenim alkalnim dimerima (356). Ispitivana su krila linija (i to posebno asimetrija) natrijuma proširenih sudarima sa Cs, Rb i K (328, 329), zatim krila linija neutralnog kalijuma, proširenih sudarima sa Cs (187, 188, 217) i Ar (250), potencijal interakcije između K i Ar (235, 236, 275) i uticaj K–Rb sudara na linije K u sudarnoj aproksimaciji (260, 291, 297).

Razmatrani su i interferentni i difuzni kontinuumi u Rb_2 spektru (285, 318, 354), triplet–tripletni prelazi u gustim parama litijuma (330), tripletni sateliti u spetkru homonuklearnih moelkula alkalija (316, 367), sateliti u linijama alkalnih metala (144, 190, 221, 319), difuzne trake u absorpcionim i emisionim spektrima Li, Li_2, Na, Na_2, K, K_2, i Rb (251, 252, 283, 284, 316, 317, 320, 321, 322, 354, 357, 365) i tripletne satelitske trake u krilima spektralnih linija alkalija (177, 189, 192, 210, 219, 262, 263, 293, 294, 331). Osim toga izučavan je i uticaj sudarnih procesa na oblik linije, u vezi sa problemom redistribucije i prenosa zračenja (140, 161, 180, 298).

Uvid u doprinos jugoslovenskih istraživača može se postići i analizom Bibliografija o oblicima i pomacima atomskih linija u periodu od prvog rada u ovoj oblasti objavljenog 1889. pa do 1978. (Fuhr et al. 1972, 1974, 1975, 1978 – potpune reference su date posle uvoda u drugi deo). Među 16 naučnika koji su u ovom periodu zastupljeni sa najvećim brojem referenci, nalaze se i 4 jugoslovenska istraživanja (vidi Tabelu 3).

TABLES AND FIGURES – TABELE I SLIKE

Table 1. Number of articles, authors, B.Sc., M.Sc., and Ph.D. theses in the period 1962–1985.
Tabela 1. Broj radova, autora, diplomskih, i magistarskih radova i doktorskih disertacija u periodu 1962–1985.

Year godina	No of publications Br. članaka	No of authors Br. autora	B.Sc. Dipl.	M.Sc. Mag.	Ph D. Dokt.
1962	1	1			
1963	0				
1964	2	2			
1965	1	1			
1966	0				
1967	0				
1968	2	4			
1969	4	4		1	
1970	15	13			
1971	11	9	1	2	
1972	10	11			1
1973	10	3	2	1	
1974	16	16	1		1
1975	14	15	2	1	
1976	23	16	1	1	
1977	13	14	1	1	1
1978	23	16		1	1
1979	17	14		1	
1980	30	19	1		
1981	26	17	1		1
1982	46	19	1		2
1983	31	19		1	
1984	41	22		1	1
1985	35	21		1	1

Table 2. Atom and ion Stark broadening parameters w and d measured by Yugoslav scientists. With a is denoted Josephson type plasma source; b – pulsed arc; c – T–tube; d – wall stabilized arc; e – Z–pinch; f – shock tube; g – pulsed discharge in a holow cathode.
Tabela 2. Atomi i joni za koje su Jugoslovenski istraživači merili Štarkove parametre w i d. Sa a je označen izvor plazme Džozefsonovog tipa; b – impulsni luk; c – T–cev; d – zidno–stabilisani luk; e – Z–pinč; f – udarna cev; g – Varnično pražnjenje sa šupljom katodom

Element Element	No of lines for which is measured Broj linija za koje je mereno w	 d	Plasma source izvor plazme	T(K)	References Reference
He I	2	2	a, b	3700–39000	23, 358
Li I	2	2	c	15000–26000	113, 119

Table 2 (continued)

C I	9	–	d	12500–12700	40, 51, 72, 162
F I	28	9	c, d, e	17500–36200	39, 107, 120 203, 295
Na I	2	2	c	15000–26000	85, 106, 113 119
Al I	3	–	c	17500	173, 208
Si I	10	10	c	8700–25000	50, 54, 55, 70, 258
Cl I	7	3	b, e	8800– 9700	18, 19, 20, 33
Ar I	9	–	d	10100–12500	36, 45, 46
K I	2	2	c	15000–26000	85, 113, 119
Rb I	2	2	c	15000–26000	113, 114, 119
Cs I	1	1	c	15000–26000	173, 208, 248, 363
Ne I	20	20	c	12000–25000	258, 255, 324, 359
Co I	5	5	c	13700–18100	254, 258, 287
Ni I	1	1	c	13700–18100	258
Cu I	2	2	c	13700–18100	258
Zn I	3	3	c	13700–18100	258
Pd I	1	1	c	13700–18100	258
Ag I	2	2	c	13700–18100	254, 258
Br I	5	–	d	9400	314, 315, 351
Hg I	3	3	c	13700–18100	258
In I	4	4	c	13700–18100	258, 259
Be II	2	2	c, e	14200–34800	32, 43, 44, 49
C II	2	–	b	26300	136
N II	16	–	b, c, e	16200–32800	17, 30, 39, 84, 205, 237, 351
O II	21	–	b	25900	81, 82
F II	5	–	b	24200	94, 101, 116
Ne II	9	–	b	28300	118, 134, 313 350
Mg II	2	3	c, e	14200–34800	43, 44, 48 49
Si II	16	16	c	8700–26000	21, 26, 43, 54, 55, 70, 103, 139, 258, 282, 288
Cl II	35	32	b, c	13330–18600	22, 28, 29, 33, 35, 43

Table 2 (Continued)

Ar II	23	23	c, e	8500–31800	7, 16, 43, 54, 58, 205, 238, 276, 313, 350
Ca II	5	5	c, e	10300–34800	34, 37, 43, 44, 48, 49
Sr II	6	6	c, e	10300–34800	34, 43, 44, 48, 49
Ba II	5	5	c, e	14200–34800	32, 43, 48, 49
P II	5	5	c	6000–20000	247, 256, 280, 286, 363
In II	1	1	c	13700–18100	258, 299
Sn II	1	1	c	16000–20000	247, 256, 280, 286, 363
Sb II	1	1	c	16000–20000	247, 256, 280, 286, 363
Cr II	3	3	c	13700–18100	258, 281
Xe II	5	–	f	8000–10000	249, 276, 290, 313, 327, 350
Kr II	3	–	f	8000–10000	290, 350
Al II	3	3	c	16000–20000	363
Pb II	3	3	c	16000–20000	247, 256, 280, 286, 363
Bi II	4	2	c	16000–20000	247, 256, 280, 286, 363
Ne III	2	–	b	34000	312
Kr III	1	–	b	26000	312
Xe III	1	–	b	27000	312
N III	4	–	b	24300	84
O III	6	–	b	25900	81, 82
Si III	9	3	b, c	8700–25600	54, 55, 70, 117
Al III	8	–	g		2
S III	16	–	b	28500	135, 158
Cl III	15	–	b	24200	94, 102, 116
Ar III	8	–	b, e	21000–31800	59, 68, 80, 205
Si IV	4	–	b	25600	117
S IV	1	–	b	28500	135, 158
Ar IV	2	–	b	20750–22200	59, 68, 80
58	360	187		Total number – Ukupan broj	

Table 3. Scientists with the most bibliographical references in spectral line shapes investigations in the period 1889–1987 according to the bibliographies by Fuhr et al (1972, 1974, 1975, 1978).

Tabela 3. Istraživači sa najviše bibliografskih jedinica u istraživanju oblika spektralnih linija u periodu 1889–1978, prema bibliografijama Fuhr et al (1972, 1974, 1975, 1978).

No. – Br.	Name – Ime	No. Ref. – Br. ref.
1.	H.R. Greim	69
2.	J. Cooper	64
3.	S.Y. Ch'en	48
4.	E.W. Smith	35
5.	N. Konjević	33
6.	I.I. Sobel'man	28
7.	G.V. Sholin	26
8.	H. Margenau	25
9–12.	H.J. Kusch	27
9–12.	S. Sahal–Bréchot	22
9–12.	J. Purić	22
9–12.	H. Van Regemorter	22
13–14.	L. Herman	21
13–14.	M. Platiša	21
15–16.	R. Granier	20
15–16.	J. Labat	20

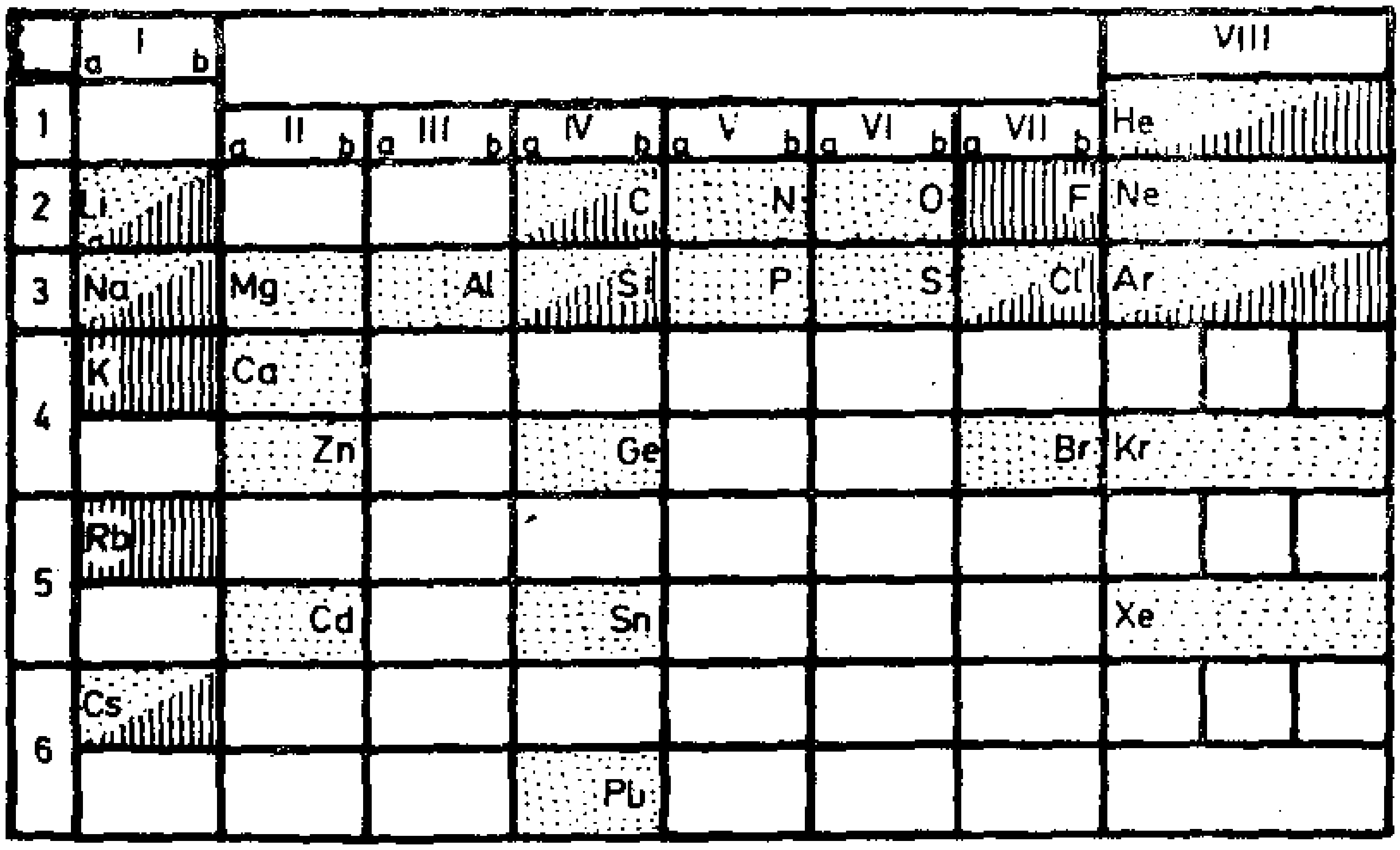

Fig. 1. Neutral emitters.

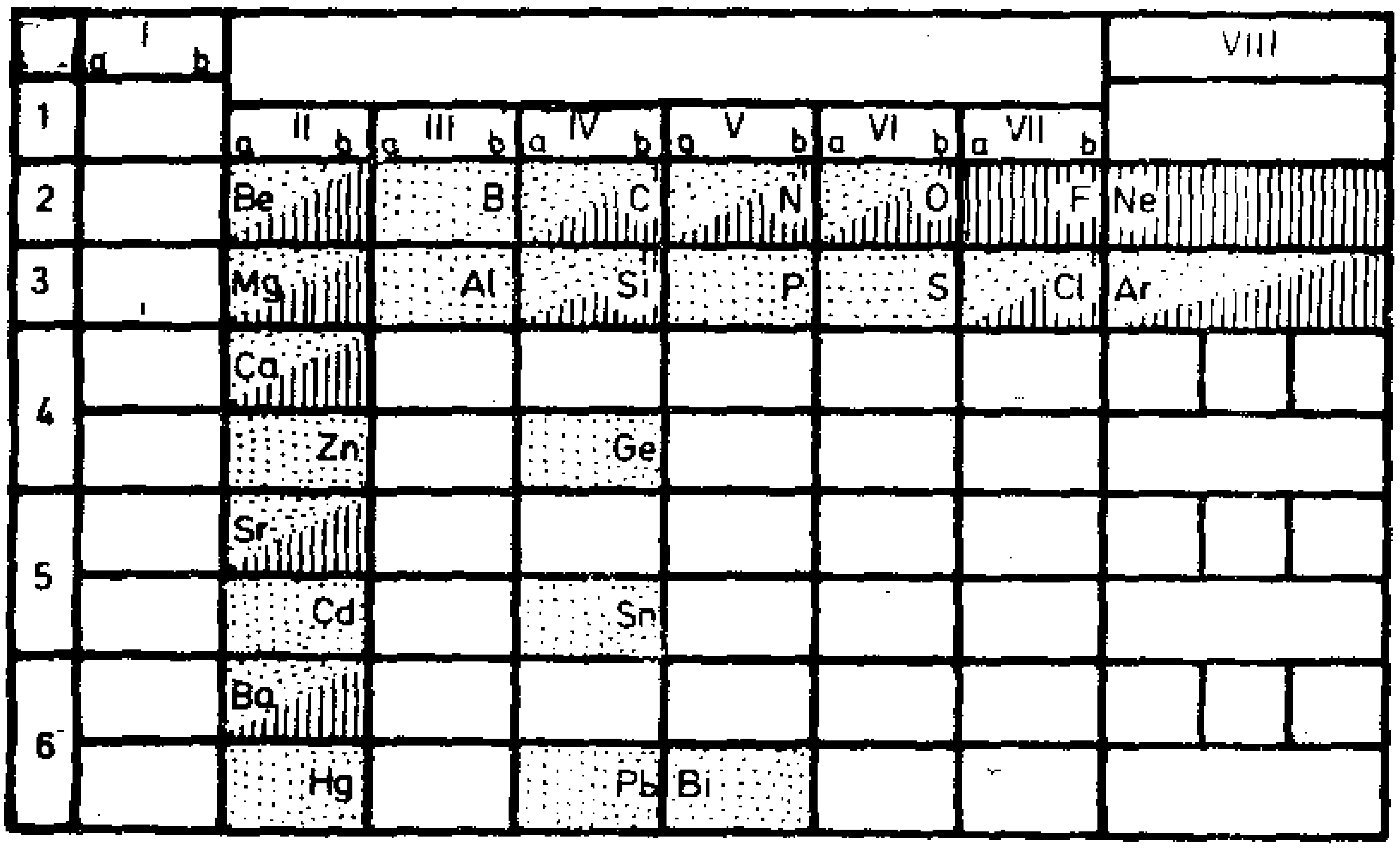

Fig. 2. Singly charged ions.

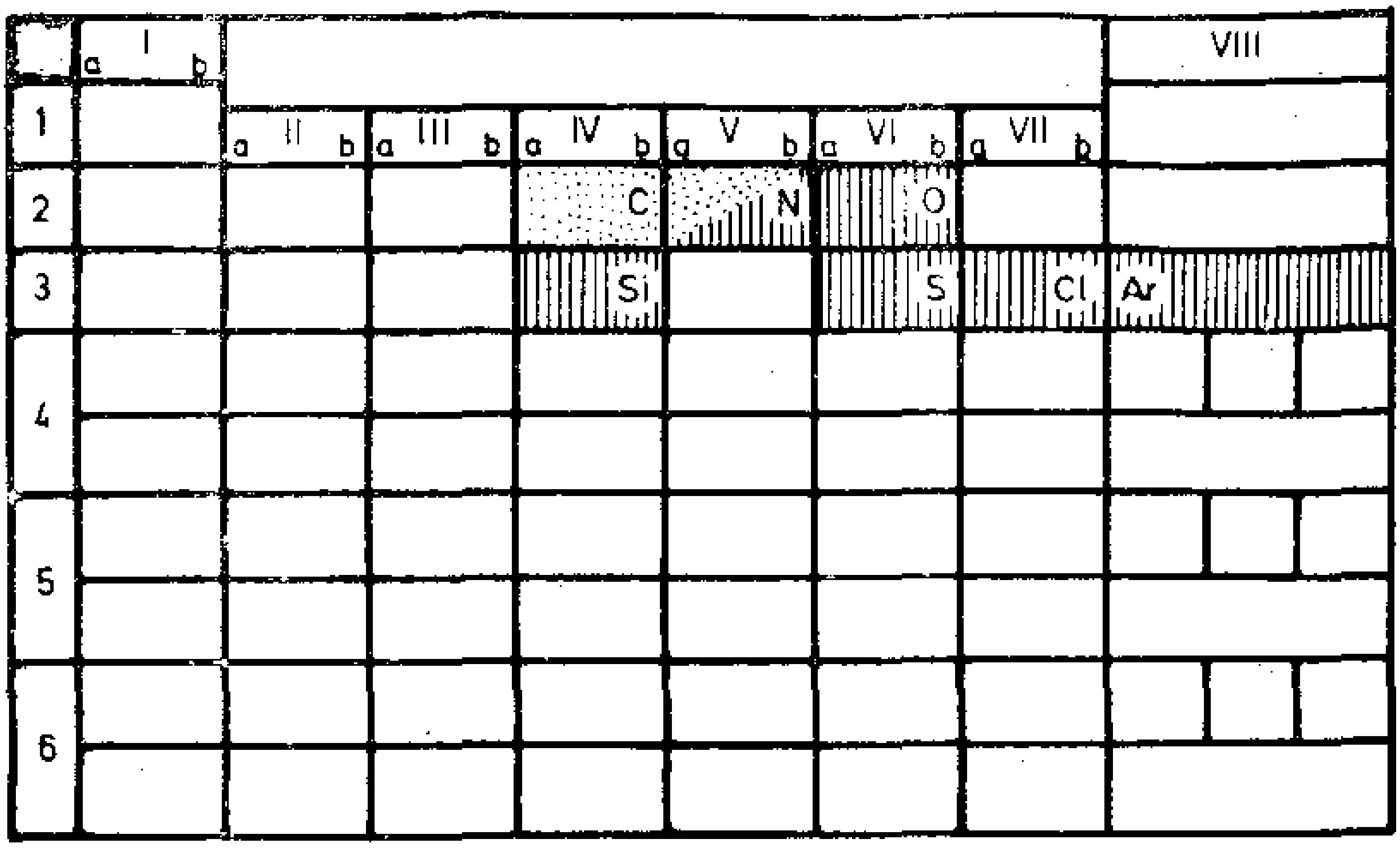

Fig. 3. Doubly charged ions.

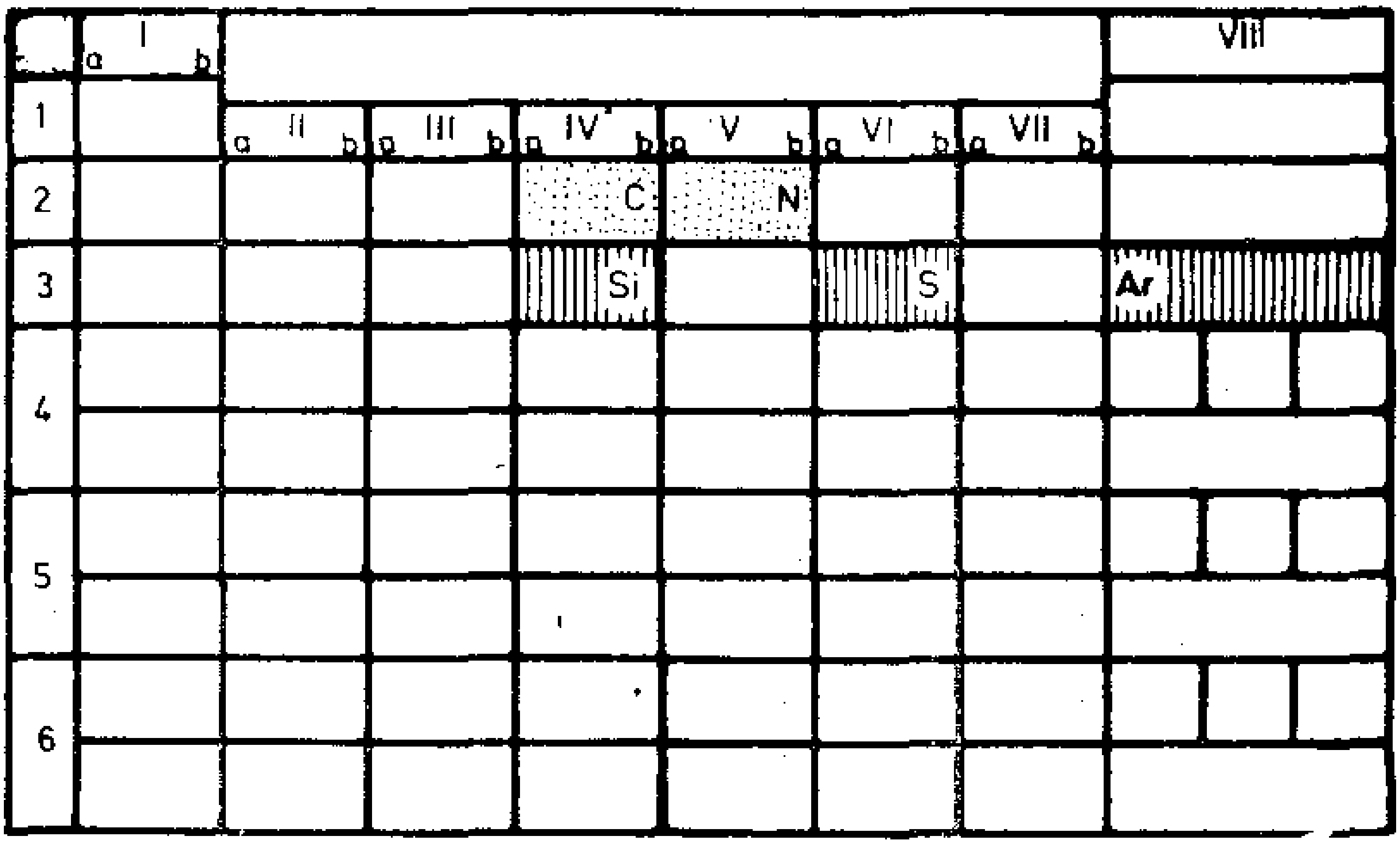

Fig. 4. Triply charged ions.

Figures 1—4. Emitters for which reliable experimental Stark broadening data exist for the most intensive lines (91, 92, 310, 311).

If only results obtained by non Yugoslav authors exist, the base is doted. The base is partially dotted and partially with lines if results of Yugoslav and non Yugoslav authors exist, and only with lines if all results are obtaines in Yugoslav laboratoreis.

Emiteri za čije najintenzivnije linije postoje pouzdani eksperimentalni podaci za Štarkove parametre (19, 82, 310, 311).

Ako postoje samo rezultati inostranih autora, podloga je tačkasta. Podloga je delimično tačkasta ako ima rezultata i naših i stranih autora a šrafirana je ako su svi postojeći rezultati dobijeni u našim laboratorijama.

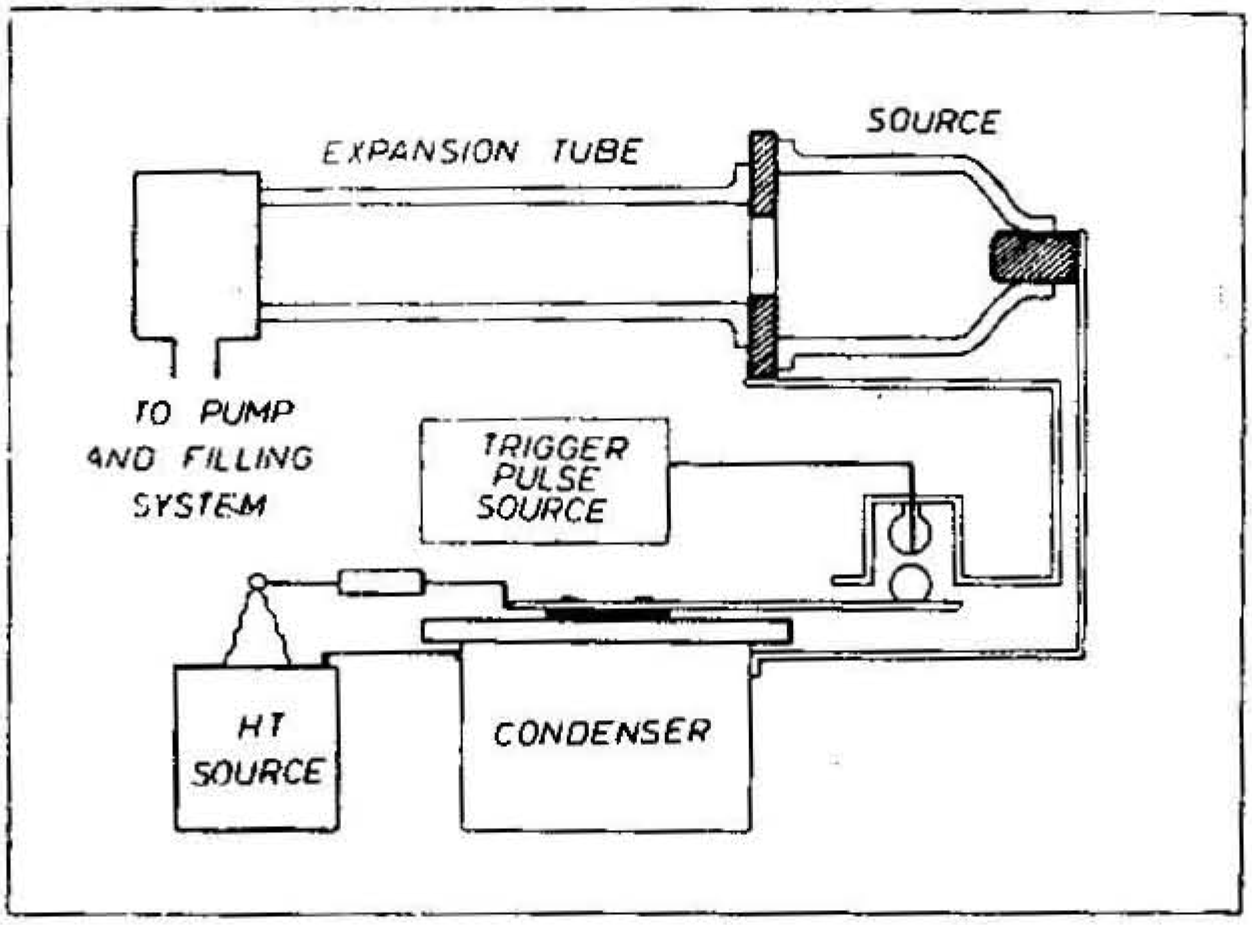

Figure 5. The plasma source of Josephson type.
Izvor plazme je Džozefsonovog tipa.

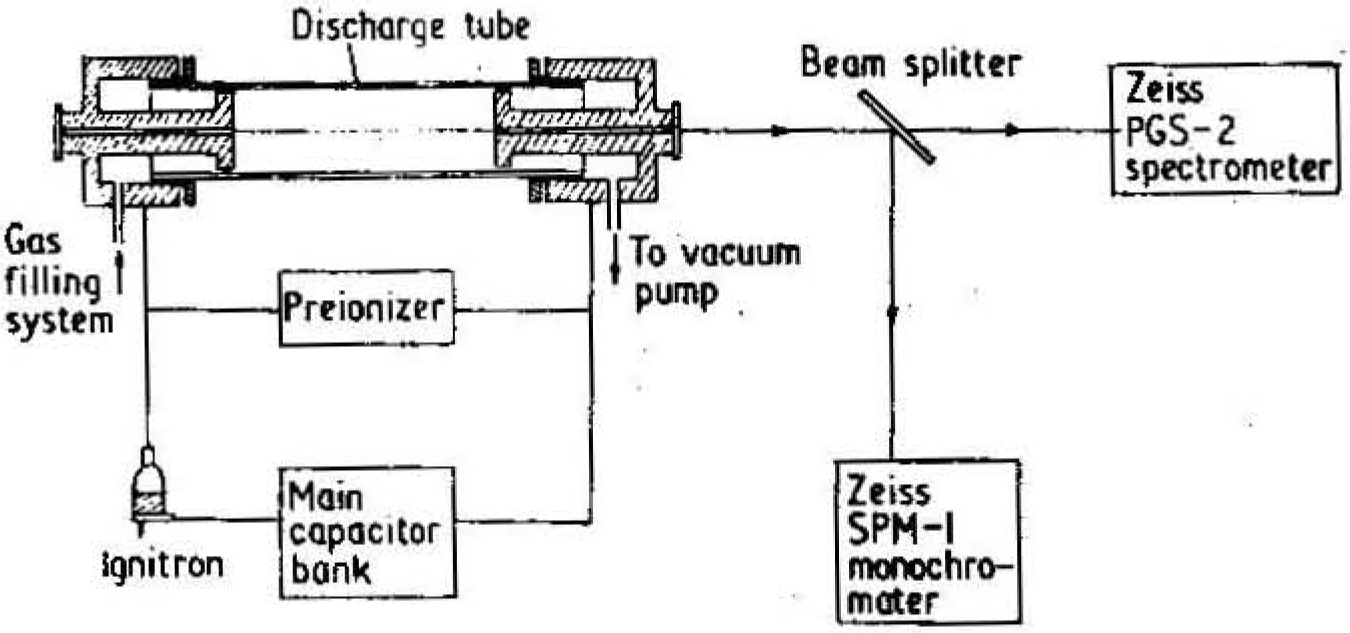

Figure 6. Pulsed arc.
Impulsni luk.

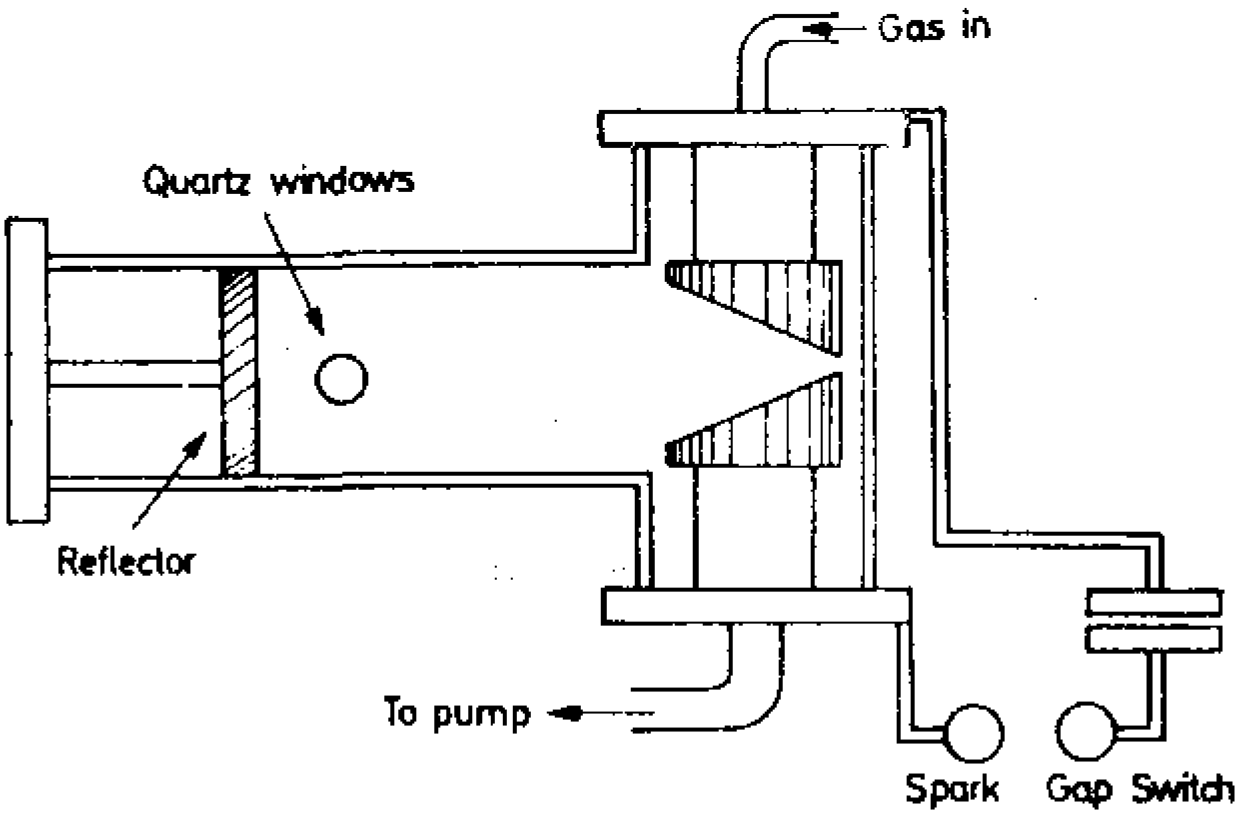

Figure 7. Electromagnetically driven T–tube.
Elektro magnetski pokretana T cev

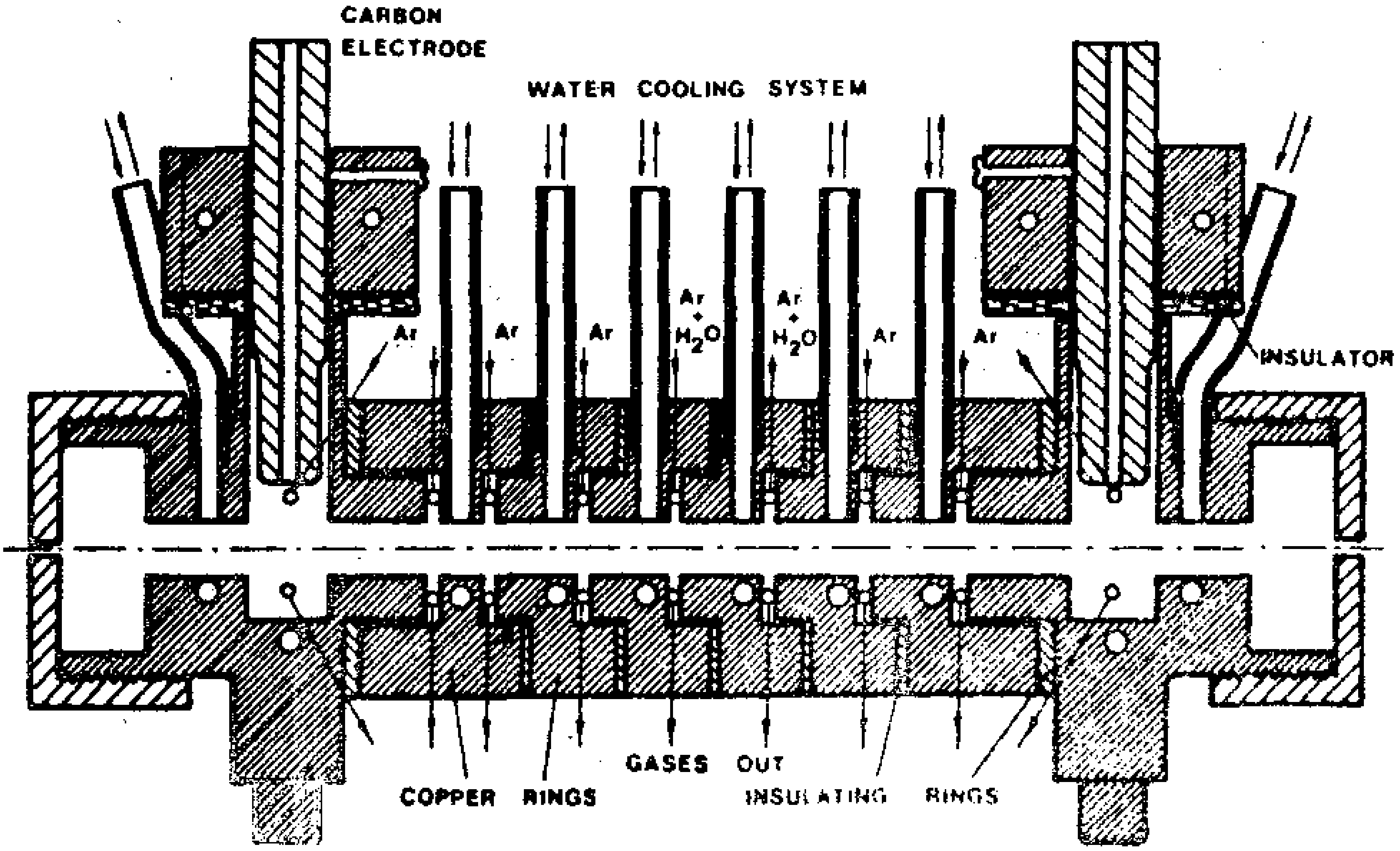

Figure 8. Wall stabilized arc.
Zidno stabilisani luk.

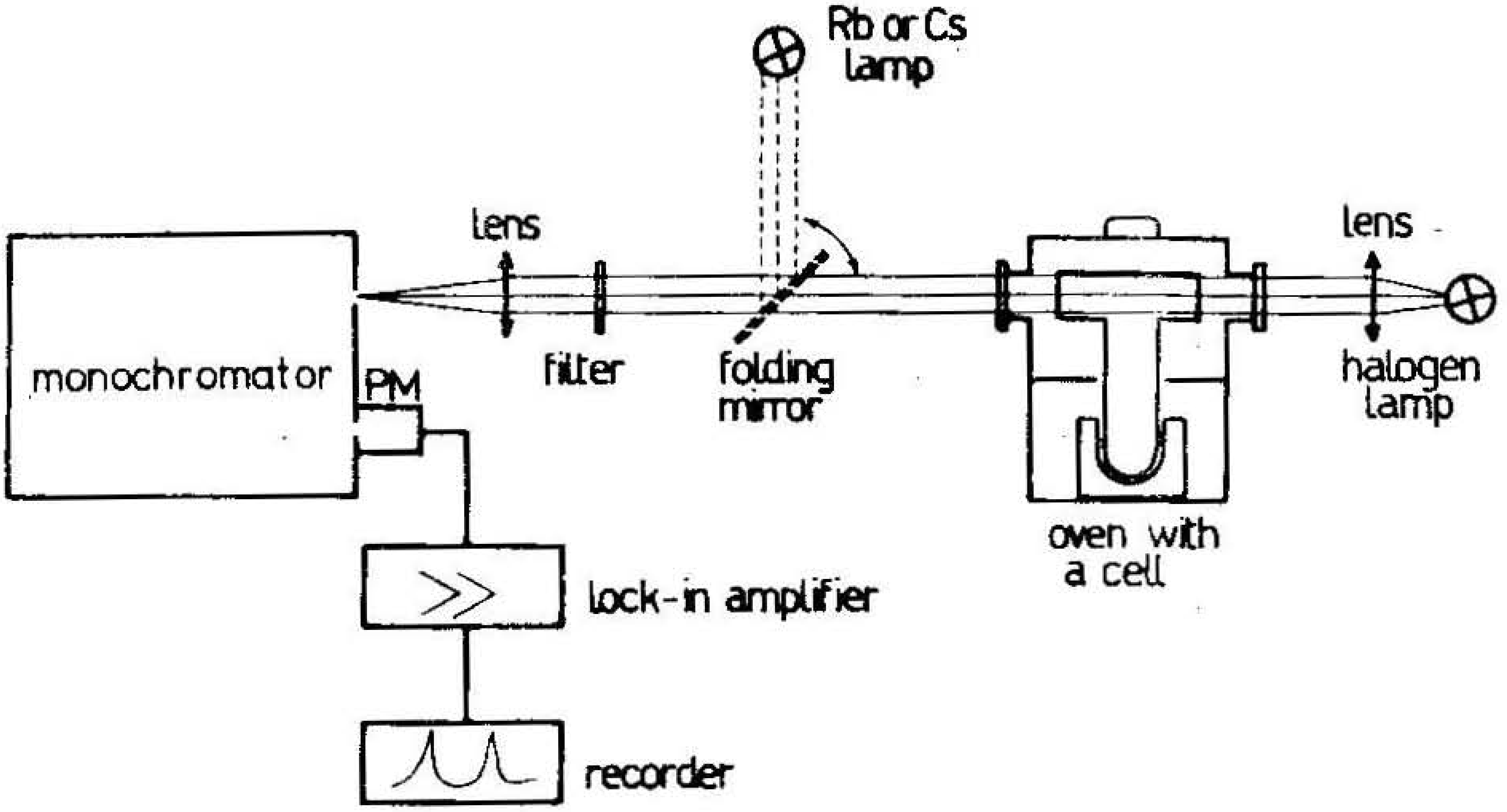

Figure 9. Low pressure lamp.
Lampa sa niskim pritiskom.

PART II – DEO II

1. INTRODUCTION

Within bibliography and citation index, references available up to the end of august 1985 are included. Besides the included citations, papers of Yugoslav scientists are largely cited in following publications which include bibliographical reviews: Dimitrijević, Konjević (1981); Institute of Physics, Activities and abstracts of papers 1962–1974; 1974–1975, 1976–1980 and 1981–1985; Fuhr et al (1972, 1974, 1975, 1978) and Teleki (1985). I tried to see personaly each paper included. From the letter of dr Lutfi Istrefi from Priština, I know the existence of 3 diploma works at University in Priština, wirtten in the period considered, namely:

1. N. Bytyqi: „On assymetrical broadening of spectral lines in plasma" (in albanian), Diploma work 1981.
2. Gëzim Kllobocishta: „Spectral line profiles" (in albanian), diploma work, 1981.
3. Besnik Kondri: „Spectral line emission" (in albanian), diploma work, 1985.

Each paper of Yugoslav authors is numbered within bibliography and after, papers where the considered paper is cited are given. For citations, yet existing in the bibliography, only short data are given.

2. UVOD

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1. N. Bytyqi: „O asimetričnom širenju spektralnih linija plazme" (na albanskom), diplomski seminar, 1981.
2. Gezim Kllobocishta: „Profil spektralne linije" (na albanskom), diplomski seminar, 1981.
3. Besnik Kondri: „Emisija spektralnih linija", (na albanskom), diplomski seminar, 1985.

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4.2. Yugoslav research workers – Jugoslovenski istraživači

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of pape Br. članak
Acinger, K.	1970	1972	3
Beuc, R.	1980	1985	13
Bojović, V.	1971	1971	1
Bosanac, S.	1983	1984	2
Cekić, M.	1982	1985	3
Čelebonović, V.	1982	1982	1
Čerić, V.	1974	1974	2
Ćirković, Lj.	1968	1985	31
Ćuk, M.	1980	1985	15
Dimitrijević, M.S.	1974	1985	92
Djeniže, S.	1973	1977	11
Đurović, S.	1975	1979	2
Džimberg, V.	1981	1981	1
Glavonjić, V.	1978	1981	6
Grubor, D.	1973	1981	3
Grujić, P.	1970	1979	11
Hadžiomerspahić, D.	1972	1973	3
Istrefi, L.	1981	1982	3
Kajzer, M.	1978	1978	1
Knežević, V.	1978	1978	1
Kobilarov, R.	1982	1983	3
Koković, M.	1975	1975	1
Koledin, D.	1979	1979	1
Konjević, N.	1969	1985	90
Konjević, R.	1985	1985	1
Kostić, B.	1977	1977	1
Kršljanin, V.	1984	1985	4
Labat, J.M.	1968	1977	26
Labat, O.	1980	1981	2
Lakićević, I.S.	1973	1985	53
Lokner, V.	1980	1983	2
Manola, S.	1982	1984	4
Marić, Z.	1976	1976	1
Marinković, M.D.	1964	1964	1
Vadla, Č.	1972	1985	17
Mejaški–Tonejc, A.	1970	1972	5
Mićunović, J.	1974	1974	1
Mihajlov, A.A.	1983	1983	1
Miler, D.	1970	1973	3
Milošević, S.	1981	1985	18
Milošević, Z.	1976	1976	1
Mitrović, V.	1970	1971	2

Movre, M.	1976	1985	30
Panić, K.	1980	1980	1
Pavlov, M.	1968	1980	5
Pichler, G.	1970	1985	62
Platiša, M.	1970	1985	31
Popović, M.M.	1973	1973	1
Popović, M.V.	1972	1979	16
Popović, S.	1975	1975	1
Purić, J.M.	1968	1985	79
Radivojević, D.	1970	1971	2
Radujkov, V.	1975	1976	2
Rathore, B.	1982	1985	11
Rukavina, J.	1980	1980	1
Ruždak, V.	1974	1981	7
Sušić, R.	1973	1973	1
Škovrlj, Lj.	1978	1978	2
Šternberg, Z.W.	1978	1978	1
Terzić, M.	1975	1980	2
Urošević, V.	1973	1973	1
Uzelac, N.I.	1985	1985	1
Veža, D.	1978	1985	24
Vince, I.	1984	1985	4
Vujičić, B.T.	1982	1985	5
Vujnović, V.	1962	1984	13
Vujović, O.	1974	1974	1
Vukičević, D.	1983	1985	3

Author index and abreviations
Indeks autora i skraćenice

Author index and abreviations
Indeks autora i skraćenice

Author index — Indeks autora

Abreviations — Skraćenica

AIAAJ — American Institute of Aeronautics and Astronautics Journal
C.R.H. Acad. Sci. — Comptes Rendus Hebdomadaires de l'Academie des Scineces
ECAMP — European Conference on Atomic and Molecular Physics
ECAP — European Conference on Atomic Physics
EGAS — Europana Group for Atomic Spectroscopy
ERMA — European Regional Meeting on Astronomy
ESCAMPIG — European Study Conference on Atomic and Molecular Physics of Ionized Gases
ETF — Elektro—tehnički fakultet
IAU — International Astronomical Union
ICPIG — International Conference on the Physics of Ionized Gases
ICSLS — International Conference on Spectral Line Shapes
IVTAN — Institut Vysokikh Temperatur Akademii Nauk
JETP — Journal of Experimental and Theoretical Physics
JQSRT — Journal of Quantitative Spectroscopy and Radiative Transfer
LGU — Leningradskij Gosudarstvenyj Universitet
(Kongres) MFAJ — (Kongres) Matematičara fizičara i astronoma Jugoslavije
NBS — National Bureau of Standards
PMF — Prirodno—matematički fakultet
SPIG — Symposium on the Physics of the Ionized Gases
Z. Naturforsch. — Zeitschrift für Naturforschung
Z. Physik — Zeitschrift für Physik

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MILAN S. DIMITRIJEVIĆ

LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA AND SERBIA III (1989 - 1993)

(Bibliography and citation index)

ISTRAŽIVANJE OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI I SRBIJI III (1989 - 1993)

(Bibliografija i indeks citata)

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CONTENTS-SADRŽAJ

SUMMARY: First part of the publication contains review and analysis of the results of spectral line shapes investigations in Yugoslavia and Serbia in the period 1989--1993. In the second part, the bibliography of the contributions of Yugoslav and Sebian scientists is given, together with the citation index.

REZIME: U prvom delu publikacije dat je pregled i analiza istraživanja oblika spektralnih linija u Jugoslaviji i Srbiji u periodu 1989--1993 godine. U drugom delu data je bibliografija radova jugoslovenskih i srpskih istraživača, sa istorijatom uticaja svakog objavljenog dela na savremenu nauku, što je urađeno navođenjem izvora u kojima su objavljeni članci citirani.

I. SPECTRAL LINE SHAPES INVESTIGATIONS IN YUGOSLAVIA AND SERBIA 1989--1993

Two previously published Bibliographies with citation index on Spectral Line Shapes Investigations in Yugoslavia, cover the period 1962 -- 1989 (Dimitrijević, 1990, 1991). From the end of 1989 up to September 1993, 241 articles concerning line shapes investigations have been published by Yugoslav authors (among them 230 by Serbian authors). In Serbia have been published as well 2 Ph. D. and 4 M. Sc. Theses. Consequently, since the first article on this topic (Vujnović et al., 1962) up to the 1993, 869 (684 by serbian authors) bibliographic items have been published by 127 Yugoslav authors(100 from Serbia, 26 from Croatia and 1 living in France).

In the considered period various problems have been investigated. Doppler broadening in a d.c. hydrogen glow discharge has been investigated for Balmer series hydrogen lines (629, 705). Stark broadening of hydrogen and hydrogen-like emitter lines, has been studied in particularly for H-beta line shift (679, 741), and hydrogen line shift in the presence of magnetic field (678, 839). Also, the attention has been paid to the study of H alpha wing assymetry in weakly non ideal plasma (699), to the investigation of hydrogen line shapes in a plane - cathode abnormal glow discharge (791) and other discharges (799, 840) and to the influence of ion dynamics (865).

Work on the experimental determination of Stark broadening parameters of nonhydrogenic atoms and ions has been continued during the considered period: Stark broadening of folowing atoms and ions has been investigated: Ar I, II, III, IV (661, 730, 858, 859); B I, II, III (783, 838, 864); Br I, II (655, 656, 657, 658, 740); C I, II (803, 838); Ca II (862, 863); Cl I, II, III (655, 658, 661); Cd II (688, 724, 725); F I, II, III, IV, V, VII (683, 723, 785, 786, 787, 843, 866); Fe II (795, 856, 857); He I (680, 698, 750, 751, 849, 858, 860); Hg I, II, III (653, 756, 782); I I, II (656, 657, 676, 690); Kr II, III (748); Na I (783); N II, III (731, 743, 781, 838); Ne I, II, III, IV, V, VI (696, 866); O II, III (726, 749, 855, 864); Pb II (756, 782); S II, III (652, 654, 661, 694, 706); Si II, III, IV (727, 784); Sn I, II (651, 782); Xe I, II, III (667, 748), Zn II (724, 745). Also, the influence of ion dynamics (663, 665, 666, 732, 733), magnetic field (680, 849) and plasma non ideality (695) has been investigated .

Using the semiclassical perturbation approach (Sahal-Bréchot, 1969a,b), the spectra of following elements have been investigated: He I (641), Li I (642, 644, 714, 716), Be I (776, 836), Na I (645, 648), Al I (777, 830), K I (647), Cu I (649), Rb I (774), Pd I (806, 810), Be II (765, 769, 823, 825), Ca II (766, 771, 819, 821, 826, 828), Hg II (757, 808), Al III (762, 820, 832), Sc III (767, 821), C IV (717, 719, 772, 773, 775, 778), Si IV (718, 720), Ti IV (767, 821), N V (768, 827), O VI (712, 779), S VI (822, 824), F VII (831, 833), Ne VIII (835), Na IX (835), Al XI (834) and Si XII (834). The influence of the perturber path deflection from straight line, due to the back reaction of neutral emitter on Stark broadening and collision phase shifts, has been investigated (721, 728, 729) as well as plasma screening effects on Stark broadening at the adiabatic limit (634) and the asymptotic behaviour of the Stark broadening A and a functions for attractive hyperbolic paths (643, 770).

Theoretical investigations of non hydrogenic emitter Stark broadening were developed in several directions. An especial effort has been done in order to investigate and test the modified semiempirical method (Dimitrijević and Konjević, 1980). The case of close perturbing levels has been studied in (637) and this approach has been applied to the lines of Bi II (817, 818), Cd II (854), I II (850), Sb II(851), Zn II (854), Pt II (760, 812, 814) and for a number of four and five time charged ion lines (807, 811, 813, 815). Moreover, a simple convergent semiclassical method for evaluation of Stark broadening parameters of neutral atom lines has been developed (636, 722, 762, 816). Approximate methods have been used and tested on numerous examples (630, 631, 707, 670, 780).

A special attention has been paid in a number of papers to the investigation of regularities and systematic trends of Stark broadening parameters (638, 639, 640, 677, 686, 691, 692, 693, 710, 711, 713, 740, 746, 747, 748, 759, 786, 800, 829, 837). Similarities of Stark broadening parameters within the same multiplets (800), supermultiplet (800), transition array (650, 800) and spectral series (710, 711, 759, 829) have been examinated. Also, systematic trends for the same type of transition within a homologous (677, 837) and isoelectronic sequence (713, 786) as well as the dependence of Stark broadening parameters on the ionization potential and on the element ordinal number, giving as the result simple formulae of astrophysical importance (686, 687, 746, 747). An investigation on similarities and regularities for line broadening due to collisions with neutral perturber has also been carried out with the special intention to improve the Van der Waals formula (638, 640, 659, 709).

Astronomical aspects of spectral line shapes research were studied in a number of publications, as the contribution of atomic collisions to the solar limb effect (697, 844), shapes, asymmetries and bisectors of solar and stellar spectral lines (669, 674, 737, 739, 790, 842, 845, 846, 847, 852, 868), Na abundance in Solar atmosphere (691, 734), spectral analysis of a white light flare (798), Fe I lines in the spectrum of Sirius (738), and Stark broadening parameters and abundances in spectra of hot stars (672, 673, 735, 736, 789). On Astronomical Observatory in Belgrade the Belgrade programme for monitoring of activity --- sensitive spectral lines of the Sun as a star, during a 11-years Solar cycle is in the course of realization. In accordance with this programme Solar activity influence on spectral lines has been investigated in several papers (662, 797, 861, 867, 969). Due to need to obtain a better connection between astronomical observations and theoretical interpretations of astrophysical spectra, the radiative transfer investigations have also been carried out (689, 704, 755, 801, 802). Moreover, the influence of the gravitational field on the shape of spectral lines of Seyfert galaxies and quasars and the influence of ion-atom collisions on the absorption of radiation in white dwarfs (793) has been studied as well.

In a number of papers, satellite and diffuse bands of NaCd (628), InHg (685), KHg (660), KCd (659), NaHg(628), satellite bands in the wings of Tl and In resonance lines (660), and metal excimers (684), have been studied. Continua, satellite and diffuse bands have been investigated also (681, 682, 703, 752), as well as laser induced chemiluminescence (753, 754).

The contribution and influence of Yugoslav and Serbian scientists in the international effort on investigation and interpretation of line shapes illustrated by the bibliography and citation index which follows, may be additionally emphasyzed by the Table 1. Here, scientists with the most bibliographical references in this field in the period 1889 - 1992, according to bibliographies by Fuhr et al. (1972, 1974, 1975, 1978, 1993), are presented.

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Fuhr, J.R., Wiese, W.L., Roszman, L.J.: 1972, *Bibliography on Atomic Line Shapes and Shifts (1989 through March 1972)*, NBS Spec.Publ. 366, U.S.Dept. of Commerece, Washington D.C.

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Sahal-Bréchot, S.: 1969a, Astron. Astrophys. **1**, 91.

Sahal-Bréchot, S.: 1969b, Astron. Astrophys. **2**, 322.

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TABLES --- TABELE

Table 1. Scientists with the most bibliographical references in spectral line shapes investigations in the period 1889 - 1992 according to the bibliographies of Fuhr et al. (1972, 1974, 1975, 1978, 1993).

Tabela 1. Istraživači sa najviše bibliografskih jedinica u istraživanju oblika spektralnih linija u periodu 1889 - 1992, prema bibliografijama Fuhr-a i dr.(1972, 1974, 1975, 1978, 1993).

No. - Br.	Name - Ime	No. of references Broj referenci
1-2.	H.R.Griem	107
1-2.	M.S.Dimitrijević	107
3.	J.Cooper	105
4.	N.Konjević	82
5.	J.Purić	70
6.	S.Sahal-Bréchot	53
7.	S.Y.Ch'en	51
8.	J.Szudy	48
9.	E.W.Smith	45
10.	M.Platiša	44
11-12.	J.Labat	41
11-12.	R.W.Lee	41
13.	E.L.Lewis	37
14.	И.И.Собельман	33

ISTRAŽIVANJA OBLIKA SPEKTRALNIH LINIJA U JUGOSLAVIJI I SRBIJI 1989 -- 1993

Dve prethodno objavljene Bibliografije sa indeksom citata o istraživanjima oblika spektralnih linija u Jugoslaviji, pokrivaju period 1962 -- 1989. (Dimitrijević, 1990, 1991). U periodu od kraja 1989. do septembra 1993. godine, objavljen je 241 članak koji se odnosi na istraživanje oblika linija (medju njima su 230 članaka srpskih autora). U Srbiji su takodje odbranjene i 2 doktorske i 4 magistarske teze. Shodno tome, od prvog članka u ovoj oblasti (Vujnović i dr., 1962) pa do septembra 1993, objavljeno je 869 (684 od strane srpskih autora) bibliografskih jedinica od ukupno 127 (100 iz Srbije, 26 iz Hrvatske i 1 makedonac koji živi u Francuskoj) jugoslovenskih autora.

U razmatranom periodu istraživani su različiti problemi. Za Balmerovu seriju vodonikovh linija istraživano je Doplerovo širenje u d.c. vodoničnom tinjavom pražnjenju (629, 705). Štarkovo širenje linija vodonika i vodoniku sličnih emitera, posebno je proučavano u slučaju pomaka linije H beta (679, 741), i u slučaju pomaka vodonikovih linija u prisustvu magnetnog polja (678, 839). Pažnja je takodje poklonjena proučavanju asimetrije krila linije u slabo neidealnoj plazmi (699), istraživanju oblika vodoničnih linija u neregularnom tinjavom pražnjenju sa ravnom katodom (791) i drugim pražnjenjima (799, 840) i uticaju dinamike jona (865).

Veliki je trud uložen i u eksperimentalno odredivanje parametara Štarkovog širenja nevodoničnih atoma i jona. Bilo je istraživano Štarkovo širenje sledećih atoma i jona: Ar I, II, III, IV (661, 730, 858, 859); B I, II, III (783, 838, 864); Br I, II (655, 656, 657, 658, 740); C I, II (803, 838); Ca II (862, 863); Cl I, II, III (655, 658, 661); Cd II (688, 724, 725); F I, II, III, IV, V, VII (683, 723, 785, 786, 787, 843, 866); Fe II (795, 856, 857); He I (680, 698, 750, 751, 849, 858, 860); Hg I, II, III (653, 756, 782); I I, II (656, 657, 676, 690); Kr II, III (748); Na I (783); N II, III (731, 743, 781, 838); Ne I, II, III, IV, V, VI (696, 866); O II, III (726, 749, 855, 864); Pb II (756, 782); S II, III (652, 654, 661, 694, 706); Si II, III, IV (727, 784); Sn I, II (651, 782); Xe I, II, III (667, 748), Zn II (724, 745). Istraživan je takodje uticaj dinamike jona (663, 665, 666, 732, 733), magnetnog polja (680, 849) i neidealnosti plazme (695).

Koristeći semiklasični perturbacioni prilaz (Sahal-Bréchot, 1969a,b), istraživani su spektri sledećih elemenata: He I (641), Li I (642, 644, 714, 716), Be I (776, 836), Na I (645, 648), Al I (777, 830), K I (647), Cu I (649), Rb I (774), Pd I (806, 810), Be II (765, 769, 823, 825), Ca II (766, 771, 819, 821, 826, 828), Hg II (757, 808), Al III (762, 820, 832), Sc III (767, 821), C IV (717, 719, 772, 773, 775, 778), Si IV (718, 720), Ti IV (767, 821), N V (768, 827), O VI (712, 779), S VI (822, 824), F VII (831, 833), Ne VIII (835), Na IX (835), Al XI (834) and Si XII (834). Istraživan je i uticaj odstupanja putanje perturbera od prave linije, usled povratne reakcije neutralnog emitera, na Štarkovo širenje i fazni pomak (721, 728, 729) kao i uticaj Debajevog ekraniranja na Štarkovo širenje na adijabatskoj granici (634) i asimptotsko ponašanje A i a funkcija u teoriji Štarkovog širenja, za atraktivne hiperboličke putanje (643, 770).

Teorijska istraživanja Štarkovog širenja nevodoničnih emitera, razvijala su se u više pravaca. Poseban napor je učinjen da se razvije i testira modifikovani semiempirijski metod (Dimitrijević i Konjević, 1980). Slučaj bliskih perturbacionih nivoa proučavan je u (637) a oval prilaz je primenjen na linije Bi II (817, 818), Cd II (854), I II (850), Sb II(851), Zn II (854), Pt II (760, 812, 814) i za linije četvorostruko i petostruko naelektrisanih jona (807, 811, 813, 815). Razvijen je i prosti konvergentni semiklasični metod za parametre Štarkovog širenja linija neutralnih atoma (636, 722, 762, 816). Približni metodi su korišćeni i testirani na brojnim primerima (630, 631, 707, 670, 780).

U brojnim radovima su istraživane regularnosti i sistematski trendovi parametara Štarkovog širenja (638, 639, 640, 677, 686, 691, 692, 693, 710, 711, 713, 740, 746, 747, 748, 759, 786, 800, 829, 837). Istraživane sličnosti parametara Štarkovog širenja u okviru istog multipleta (800), supermultipleta (800), skupova prelaza (650) i spektralnih serija (710, 711, 759, 829), kao i sistematski trendovi za isti tip prelaza u homolognim (677, 837) i izoelektronskim nizovima (713, 786) a osim toga i zavisnost parametara širenja od rednog broja elemenata i jonizacionog potencijala, što je kao rezultat dalo proste formule, koje su od interesa za astrofiziku (686, 687, 746, 747). Takođe je izvedeno istraživanje sličnosti i regularnosti u slučaju linija proširenih sudarima sa neutralnim perturberima, sa ciljem da se poboljša Van der Waalsova formula (638, 640, 659, 709).

Astronomski aspekti istraživanja spektralnih linija proučavani su u brojnim prilozima. Istraživan je doprinos atomskih sudara sunčevom limb efektu (697, 844), oblici, asimetrije i bisektori sunčevih i zvezdanih spektralnih linija (669, 674, 737, 739, 790, 842, 845, 846, 847, 852, 868), zastupljenost Na u Sunčevoj atmosferi (691, 734), spectralna analiza hromosferske erupcije u beloj svetlosti (798), Fe I linije u spektru Sirijusa (738), i, parametri Štarkovog širenja i zastupljenost hemijskih elemenata u spektrima toplih zvezda (672, 673, 735, 736, 789). Na Astronomskoj opservatoriji u Beogradu u toku realizacije je Beogradski program po kome se u toku 11 godišnjeg sunčevog ciklusa prate spektralne linije Sunca kao zvezde, koje su osetljive na njegovu aktivnost. U skladu sa ovim programom uticaj sunčeve aktivnosti je istraživan u nekoliko članaka (662, 797, 861, 867, 969). Takodje su vršena i istraživanja prenosa zračenja, usled potrebe da se poboljša veza izmedju astronomskih posmatranja i teorijske interpretacije astrofizičkih spektara (689, 704, 755, 801, 802). Izučavan je i uticaj gravitacionog polja na oblik spektralnih linija Sejfertovih galaksija i kvazara kao i uticaj jon-atomskih sudara na apsorpciju zračenja belih patuljaka (793).

U nizu članaka, izučavani su sateliti i difuzne trake NaCd (628), InHg (685), Khg (660), KCd (659), NaHg(628), satelitske trake na krilima rezonantnih linija Tl i In (660), i metalnih ekscimera (684). Takođe su proučavani kontinuumi, sateliti i difuzne trake (681, 682, 703, 752),kao i laserski indukovana hemiluminescencija (753, 754).

Uticaj jugoslovenskih i srpskih stvaralaca i njihov doprinos međunarodnim naporima na istraživanju i interpretaciji profila spektralnih linija, ilustrovan bibliografijom sa indeksom citata, koja je data u drugom delu, može se dodatno istaći pomoću Tabele 1. Tu su pretstavljeni naučnici sa najviše bibliografskih referenci u ovoj oblasti u periodu 1889-1992, prema bibliografijama koje su objavili Fuhr i dr. (1972, 1974, 1975, 1978, 1993).

II. BIBLIOGRAPHY AND CITATION INDEX
BIBLIOGRAFIJA I INDEKS CITATA

INTRODUCTION

The bibliography with the citation index is divided in three parts. In the first and second part are given the citation index of articles from 1962--1985 and 1985-1989 period respectively, given in Dimitrijević (1990, 1991), with the same numeration. Moreover, the number in brackets after the number of an article, if exists, denotes that at least one author is from Serbia. In such a manner the corresponding bibliography for Serbia is included as well. In the third part is the bibliography of articles up to the september of 1993 (1989--1993 period and the bibliographical items not included in Dimitrijević (1990, 1991)) and the corresponding citation index. Besides the included citations, papers of Yugoslav scientists are largely cited in the bibliographical reviews: Dimitrijević (1991), Fuhr and Lesage (1993) and Atanacković-Vukmanović and Dimitrijević (1992). I tried to see personally each paper included. After each paper of Yugoslav authors, data on articles where the considered paper is cited are given. For citations already existing in the bibliography of Yugoslav authors, only short data are given.

I am indebted to the Referal center of the Library of Matica Srpska who enabled me to search Science citation index.

UVOD

Bibliografija sa indeksom citata podeljena je u tri dela. U prvom i drugom delu dat je indeks citata članaka iz perioda 1962--1985 i 1985--1989 respektivno, koji su ušli u prethodne preglede (Dimitrijević, 1990, 1991), sa istom numeracijom. Osim toga, broj u zagradi iza rednog broja članka ako postoji, označava da je najmanje jedan autor iz Srbije. Na taj način prisutna je i odgovarajuća bibliografija za Srbiju. U trećem delu je bibiliografija članaka do septembra 1993 (period 1989--1993 i bibliografske jedinice koje nisu uključene u prethodne preglede (Dimitrijević, 1990, 1991)) i odgovarajući indeks citata. Osim uključenih citata, članci Jugoslovenskih autora su u velikom broju citirani u bibliografskim pregledima: Dimitrijević (1991), Fuhr i Lesage (1993) i Atanacković-Vukmanović i Dimitrijević (1992). Svaki uključeni članak pokušao sam da vidim lično. Posle svakog članka Jugoslovenskih autora, dati su podaci o člancima gde je razmatrani članak citiran. Za članke koji već postoje u bibliografiji jugoslovenskih autora, dati su samo skraćeni podaci.

Dugujem zahvalnost Referalnom centru Biblioteke Matice srpske gde mi je omogućeno da pretražim Science citation index

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III. APPENDIX --- PRILOG

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58.	Lanz, T., Dimitrijević, M. S., Artru, M. C.: 1988, Astron. Astrophys. **192**, 299.	34
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III. 2. Yugoslav scientists --- Jugoslovenski istraživači

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Acinger, K.:	1970	1972	3
Arsenijević, J.:	1987	1993	6
Atanacković--Vukmanović, O.:	1985	1993	18
Azinović, D.:	1989	1990	2
Beuc, R.:	1980	1989	23
Bajin, I.:	1993	1993	1
Bajović, S. V.:	1993	1993	1
Bojović, V.:	1971	1971	1
Bosanac, S.:	1982	1987	4
Božin, J.:	1992	1992	1
Brnović, M. J.:	1992	1992	2
Bukvić, S.:	1992	1993	3
Bzenić, S.:	1990	1991	2
Cekić, M.:	1983	1984	4
Čelebonović, V.:	1982	1982	1
Čerić, V.:	1974	1974	2
Ćirković, Lj.:	1968	1987	38
Ćuk, M.:	1980	1991	29
Cupać, S.:	1991	1991	1
Dimitrijević, M. S.:	1974	1993	256
Djeniže, S.:	1973	1993	61
Djurić, Z.:	1988	1992	4
Djurović, S.:	1975	1993	21
Džimberg--Malčić, V.:	1981	1990	2
Erkapić, S.:	1989	1993	8
Fijan, D.:	1987	1989	8
Francuski, T.:	1989	1989	1
Glavonjić, V.:	1978	1981	6
Gnjatović, S.:	1991	1991	1
Grubor, D. P.:	1973	1981	3
Grujić, P.:	1970	1979	11
Hadžiomerspahić, D.:	1972	1973	3
Henč--Bartolić, V.:	1988	1990	2

Line Shape Investigation in Yugoslavia and Serbia III (1989-1993)

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Istrefi, L.:	1981	1991	6
Ivković, M.:	1993	1993	1
Jankov, S.:	1985	1987	4
Jelenković, B.:	1990	1992	3
Jevremović, D.:	1993	1993	1
Jovičić, Z.:	1991	1991	1
Kajzer, M.:	1978	1978	1
Karabin, M.:	1987	1992	3
Kljajić, S.:	1989	1989	1
Knežević, V.:	1978	1978	1
Kobilarov, R.:	1982	1993	18
Koković, M.:	1975	1975	1
Koledin, D.:	1979	1979	1
Konjević, N.:	1969	1993	144
Konjević, R.:	1985	1992	8
Kostić, B.:	1977	1977	1
Kršljanin, V.:	1984	1993	45
Kubičela, A.:	1986	1993	11
Labat, J. M.:	1968	1993	67
Labat, O.:	1980	1991	10
Lakićević, I. S.:	1973	1985	57
Logožar, R.:	1988	1988	2
Lokner, V.:	1980	1983	2
Malešević, M.:	1989	1989	1
Manola, S.:	1982	1989	6
Marić, Z.:	1976	1976	1
Marinković, M.:	1991	1991	1
Marinković, M. D.:	1964	1964	1
Marković--Kršljanin, S.:	1990	1991	2
Kuraica, M.:	1990	1992	3
Mićunović, J.:	1974	1974	1
Mihajlov, A. A.:	1983	1992	10
Mijatović, Z.:	1987	1993	15

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Mijović, S.:	1986	1988	3
Miler, D.:	1970	1973	3
Milosavljević, M.:	1987	1991	6
Milošević, S.:	1981	1990	32
Milošević, Z.:	1976	1976	1
Mitrović, V.:	1970	1971	2
Modrič, D.:	1986	1990	8
Movre, M.:	1976	1990	44
Nikolić, B.:	1991	1991	1
Nikolić, D.:	1993	1993	1
Palle, M.:	1986	1986	1
Panić, K.:	1980	1980	1
Panić, Z.:	1991	1991	1
Pantelić, D.:	1989	1989	1
Pavlov, M.:	1968	1993	22
Paunović, D. R.:	1990	1990	1
Pavlović, M. S.:	1991	1991	1
Pavlović, N. Z.:	1991	1991	1
Petrović, Z. Lj.:	1990	1992	2
Pichler, G.:	1970	1991	112
Pivalica, S.:	1991	1993	3
Platiša, M.:	1970	1993	60
Popović, L. Č.:	1991	1993	15
Popović, M. M.:	1973	1992	11
Popović, M. V.:	1972	1989	19
Popović, S.:	1975	1975	1
Pružljanin, G.:	1993	1993	1
Purić, J. M.:	1968	1993	125
Racković, I.:	1990	1990	1
Radivojević, D.:	1970	1971	2
Radovanov, S.:	1990	1991	2
Radujkov, V.:	1975	1986	4
Rathore, B.:	1982	1987	16
Rukavina, J.:	1980	1980	1

Name Ime	First paper Prvi članak	Last paper Zadnji članak	No. of papers Br. članaka
Ruždjak, V.:	1974	1987	8
Škovrlj, Lj. .	1978	1991	3
Skuljan, J.:	1990	1993	5
Skuljan, Lj.:	1993	1993	3
Sotirovski, P.:	1987	1992	2
Srećković, A.:	1986	1993	54
Stanković, D.:	1990	1990	1
Stanković, N.:	1991	1991	1
Stefanović, I. M.:	1990	1993	4
Šternberg, Z. W.:	1978	1978	1
Stojanović, V.:	1992	1992	1
Stokić, Z.:	1992	1992	1
Sušić, R.:	1973	1973	1
Terzić, M.:	1975	1987	5
Urošević, V.:	1973	1973	1
Todorović, K. N.:	1991	1992	2
Tonejc, A.:	1970	1972	5
Uzelac, N. I.:	1985	1993	17
Vadla, Č.:	1972	1986	19
Velikić, Z. B.:	1991	1991	1
Veža, D.:	1978	1990	48
Vince, I.:	1983	1993	30
Vrhovac, S.:	1991	1992	2
Vujičić, B. T.:	1982	1993	17
Vujnović, V.:	1962	1991	19
Vujović, O.:	1974	1974	1
Vukičević, D.:	1983	1985	3

III. 3. Index of Yugoslav authors and their coauthors

Indeks Jugoslovenskih autora i njihovih koautora

III. 4. Abreviations --- Skraćenice

AIAAJ --- American Institute of Aeronautics and Astronautics Journal
AIP --- American institute of Physics
Ann. Phys. Suppl. --- Annales de Physique Supplement
CCP/7 --- Collaborative Computational Project No 7
C. R. H. Acad. Sci. --- Comptes Rendus Hebdomadaires de l'Academie des Sciences
DIAM --- Dynamique des Ions, Atomes et Molecules
ECAMP --- European Conference on Atomic and Molecular Physics
ECAP --- European Conference on Atomic Physics
ECR --- Electron Cyclotron Resonance
EGAS --- European Group for Atomic Spectroscopy
ERAM --- European Regional Astronomy Meeting
ERMA --- European Regional Meeting on Astronomy
ESCAMPIG --- European Study Conference on Atomic and Molecular Physics of Ionized Gases
ETF --- Elektrotehnički fakultet
IAU --- International Astronomical Union
ICPIG --- International Conference on the Physics of Ionized Gases
ICSLS --- International Conference on Spectral Line Shapes
IVTAN --- Institut Vysokikh Temperatur Akademii Nauk
JETP --- Journal of Experimental and Theoretical Physics
JQSRT --- Journal of Quantitiative Spectroscopy and Radiative Transfer
LGU --- Leningradskij Gosudarstvenij Universitet
(Kongres) MFAJ --- (Kongres) Matematičara fizičara i astronoma Jugoslavije
NBS --- National Bureau of Standards
NIST --- National Institute of Standards and Technology
PMF --- Prirodno-matematički fakultet
Sing. J. Phys. --- Singaporean Journal of Physics
SPIG --- Symposium on the Physics of the Ionized Gases
Z. Naturforsch. --- Zeitschrift für Naturforschung
Z. Physik --- Zeitschrift für Physik

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Министарство просвете и спорта Републике Србије

АПРИЛСКИ ДАНИ ПРОСВЕТНИХ РАДНИКА СРБИЈЕ

ДВАНАЕСТИ СЕМИНАР ЗА ПРОФЕСОРЕ ХЕМИЈЕ

Београд, 9-ог и 10-ог априла 2001.

ХЕМИЈА ВАСИОНЕ

Милан С. Димитријевић, Астрономска Опсерваторија, Београд

Први хемијски елементи настали су у великој нуклеосинтези после Великог праска (Big Bang) у коме је настала наша васиона. У овом процесу настали су водоник, хелијум и нешто мало литијума, тако да су прве звезде садржале само ове елементе. Космос је касније обогаћиван тежим елементима који су стварани у нуклеарним процесима који су се одвијали у унутрашњости звезда а расипани у међузвездани простор експлозијама супернових. Атоми тежи од водоника и хелијума, који се налазе у нама, стварани су у звезданим унутрашњостима и Карл Саган нас због тога с правом зове децом звезда.

Каква хемијска једињења можемо очекивати у космосу и да ли се ту налазе и сложенија органска једињења су питања на која је одговор омогућио развој међузвездане спектроскопије. Чарлс Таунс (Charles Townes), који је 1964. године добио Нобелову награду за откриће масера, открио је са сарадницима 1968. године помоћу радиотелескопа, молекуле амонијака (NH_3) у међузвезданом простору, у густом облаку који лежи у правцу галактичког центра. Откриће је извршио анализом микроталасног зрачења на 1.25cm. То је био први полиатомни молекул идентификован у међузвезданој средини и то је био тек почетак. Током следеће три године, у међузвезданом простору је откривено двадесетак молекула, а међу њима вода, формалдехид, цијановодоник и ацетилен. Рођена је астрохемија и то је био почетак откривања све комплекснијих органских једињења у космосу. Данас је прихваћено да већина посматраних молекула настаје у низу реакција између молекуларних јона и молекула, комбинованих са реакцијама на површини међузвезданих честица прашине.

Нови продор у истраживању међузвезданих полиатомних молекула, био је, када је Бари Тарнер (Barry Turner), астроном са Националне радио астрономске опсерваторије у Грин Бенку (Green Bank) у Западној Вирџинији, открио микроталасне сигнале чији је узрок био цијаноацетилен HC_3N. Новооткривени молекул у космосу, припадао је ланчаним молекулима угљеника општег облика HC_nN (где је n три или веће) који су добили име цијанополиини.

Године 1975., млади професор хемије на Универзитету у Сасексу, Хари Крото (Harry Kroto), који је био и врсни познавалац микроталасне спектроскопије, заинтересовао се питањем органских молекула у космосу. Било је мало вероватно да ланци атома угљеника настају у јон-молекулским реакцијама као и простији молекули. Осим у међузвезданим облацима, полиини као и мали угљенични кластери (C_3) нађени су у омотачу око угљеничне звезде IRC+$10^0$216. Крото је претпоставио да су извор угљеничних ланчаних молекула и кластера, угљеником богати црвени џинови који притиском зрачења избацују у међузвездани простор велике количине прашине, која садржи зрнца угљеника углавном у облику аморфног графита. Крото је претпоставио да се угљенични ланци могу синтетизовати у реакцијама између угљеничних кластера, створених испаравањем графита са угљеничних зрнаца и једноставнијих молекула из околне средине. Заједно са Робертом Карлом (Robert Curl) и Ричардом Смолијем (Richard Smalley), Крото је формулисао пројекат о симулирању хемије угљеничних звезда. Резултат истраживања био је откриће молекула C_{60}, што им је донело Нобелову награду.

У раду ће бити размотрен настанак хемијских елемената у васиони, њихова распрострањеност као и развој и резултати истраживања органских међузвезданих молекула.

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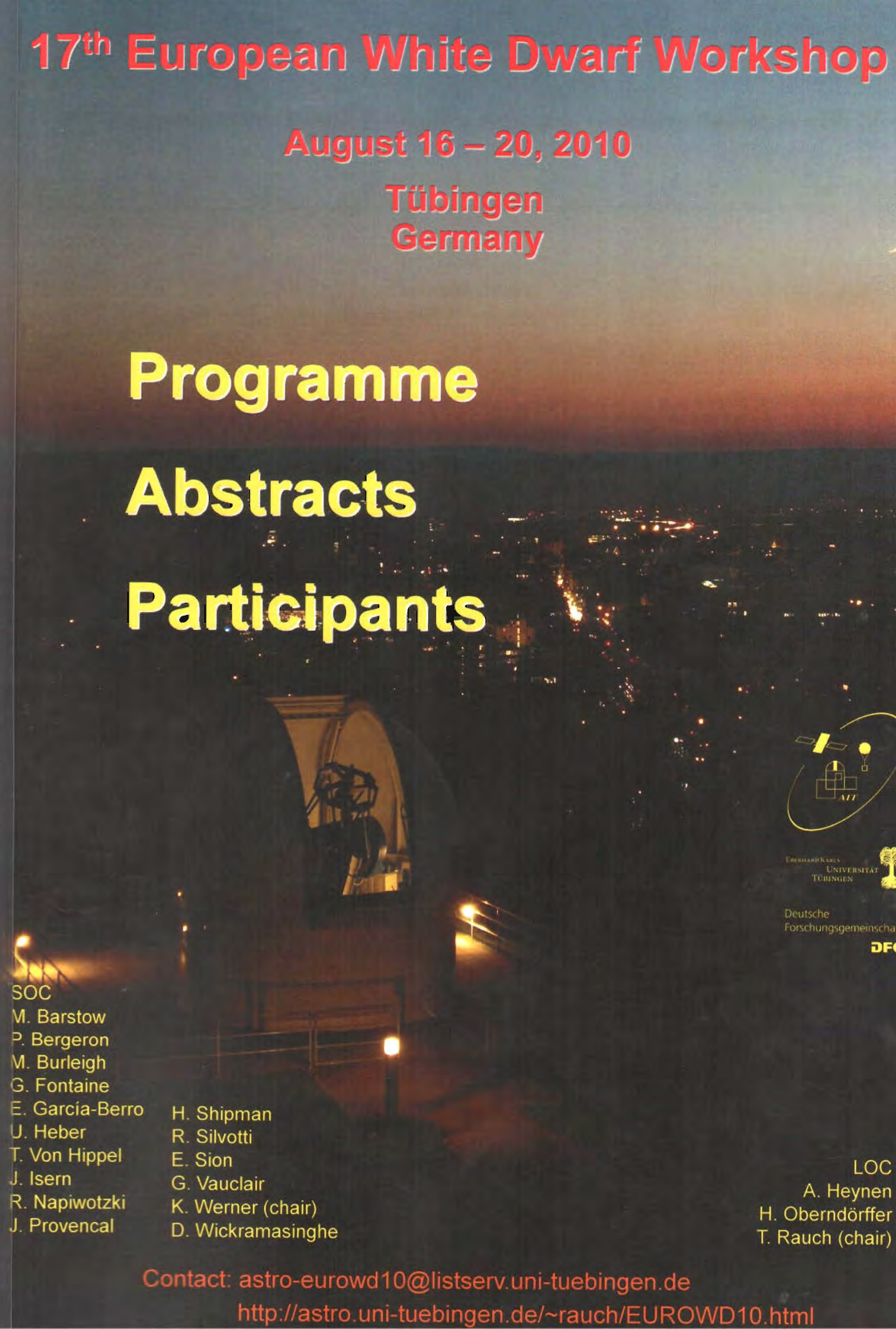

Programme

Abstracts

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ELECTRICAL CONDUCTIVITY OF PLASMA IN DB WHITE DWARF ATMOSPHERES

V. A. Srećković[1], Lj. M. Ignjatović[1],A. A. Mihajlov[1], M. S. Dimitrijević[2,3]

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The data on electrical conductivity of plasma of stars with a magnetic field or moving in the magnetic field of the other component in a binary system could be of significant interest, since they are useful for the study of thermal evolution of such objects (cooling, nuclear burning of accreted matter) and the investigation of their magnetic fields. An additional interest for data on electrical conductivity in white dwarf atmospheres may be stimulated by the search for extra-solar planets. Namely a planetary core in orbit around a white dwarf may reveal its presence through its interaction with the stellar magnetosphere. Such an interaction will generate electrical currents that will directly heat the atmosphere near its magnetic poles. This heating may be detected within the optical wavelength range as H_α emission. For investigation and modelling of such electrical currents, the data on electrical conductivity in white dwarf atmospheres will be useful. In this contribution, an adequate method for calculations of electrical conductivity of dense, partially ionized helium plasmas, convenient for the conditions in DB white dwarf atmospheres, is developed. This method represents a generalization of the modified random-phase approximation (RPA) method, and gives a possibility to estimate the real contribution of the neutral component to the static electrical conductivity of the considered helium plasmas. The static electrical conductivity of non-ideal, dense, partially ionized helium plasma was calculated within a wide range of plasma parameters of interest for DB white dwarf atmospheres with effective temperatures $1 \cdot 10^4\mathrm{K} \leq T_{eff} \leq 2 \cdot 10^4\mathrm{K}$. The method developed in this paper represents a powerful tool for research into white dwarfs with different atmospheric compositions (DA, DC etc.), and for the investigation of some other stars (M type red dwarfs, Sun etc.). Finally, the presented method provides a basis for the development of methods to describe the other transport characteristics which are important for the study of all the mentioned astrophysical objects, such as the electronic thermoconductivity in the star atmosphere layers with large electron density, electrical conductivity in the presence of strong magnetic fields and dynamic (high frequency) electrical conductivity.

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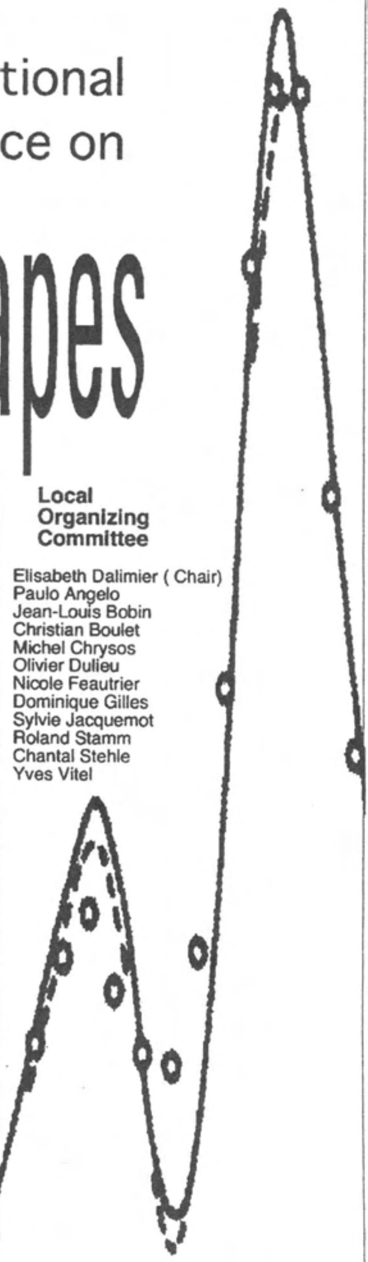

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B20 - Importance of Collisions with Charged Particles for Stellar UV Line Shapes: Cd III

Nenad Milovanovic, Milan S. Dimitrijevic, Luka C. Popovic and Zoran Simic

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Stark broadening parameters, widths and shifts, for 84 spectral lines of doubly-ionized cadmium (Cd III) have been calculated using the modified semi-empirical approach (MSE) [1,2]. Atomic parameters needed for MSE calculations were taken from [3].

Calculated spectral lines belong to the transitions $4d^9 5s - 4d^9 5p$ and $4d^9 5p - 4d^9 5d$. Widths and shifts of the spectral lines are given for temperature range of 5,000 K – 60,000 K and an electron density of 10^{23} m^{-3} [4].

We used our results to analyze behavior of Stark and Doppler line widths for series of stellar atmospheres models along HR diagram [5]. Behavior of Stark and Doppler spectral line widths in stellar atmospheres were calculated for Cd III 5p $^3F^o_3 - 5d\ ^3G_3$ (_= 144.754 nm).

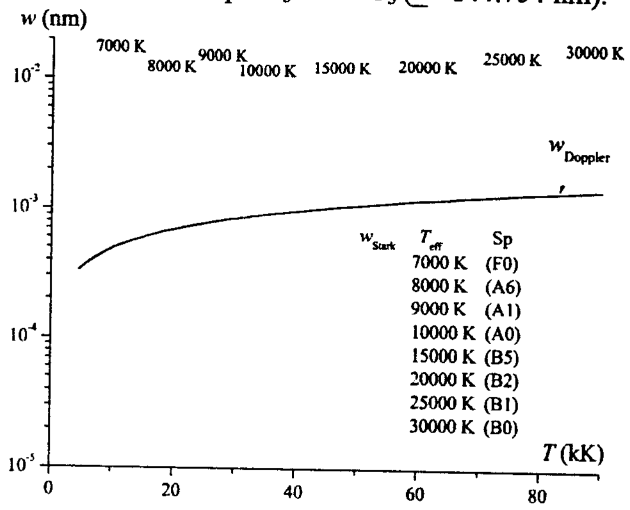

Figure 1: Stark widths (FWHM) (thinner lines) and Doppler width (thicker line) for selected spectral line (see text) as a function of atmospheric layer temperatures.

In Fig. 1 one can see that Stark widths are lager than Doppler ones for stars with lower effective temperatures (T_{eff}). For stars with higher effective temperatures, Stark broadening is more important than Doppler one for deeper atmospheric layers (larger layer temperature T).

We had shown that the Stark broadening in stellar atmospheres with higher values of surface gravity is significantly larger than Doppler broadening. For stars with surface gravity log $g = 2$, Stark broadening is comparable to Doppler widths only for deeper hot atmospheric layers.

We also analyzed influence of Stark and Doppler widths of same spectral line for various DA and DB white dwarfs stellar atmospheres taken from [6]. Stark broadening is by one or two order of magnitudes higher than Doppler one. Consequently, with the increases in pressure, electron density or effective temperature in DA and DB white dwarf models, the importance of Stark broadening increases as well.

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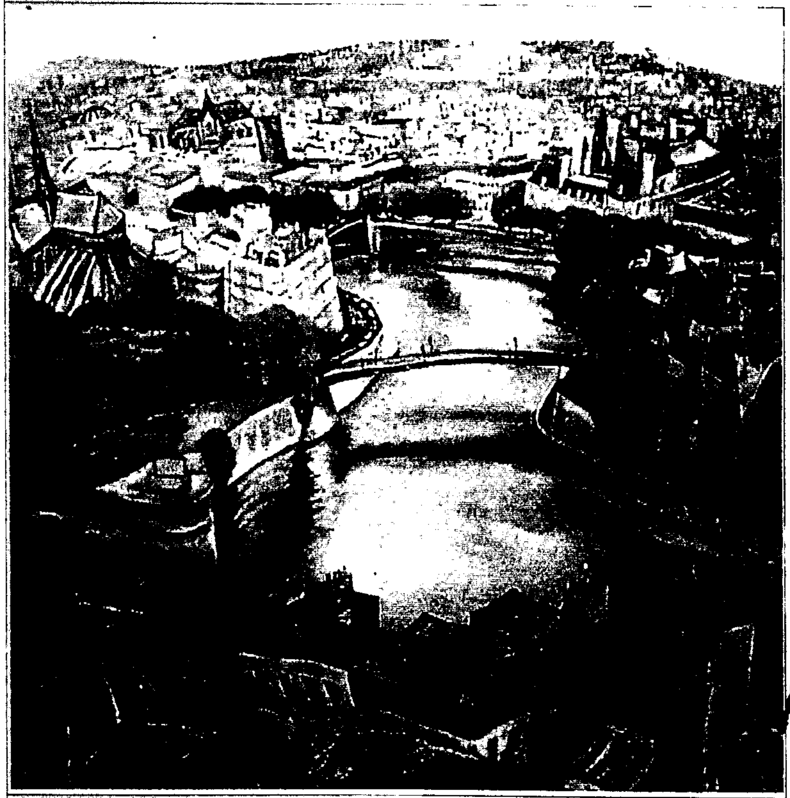

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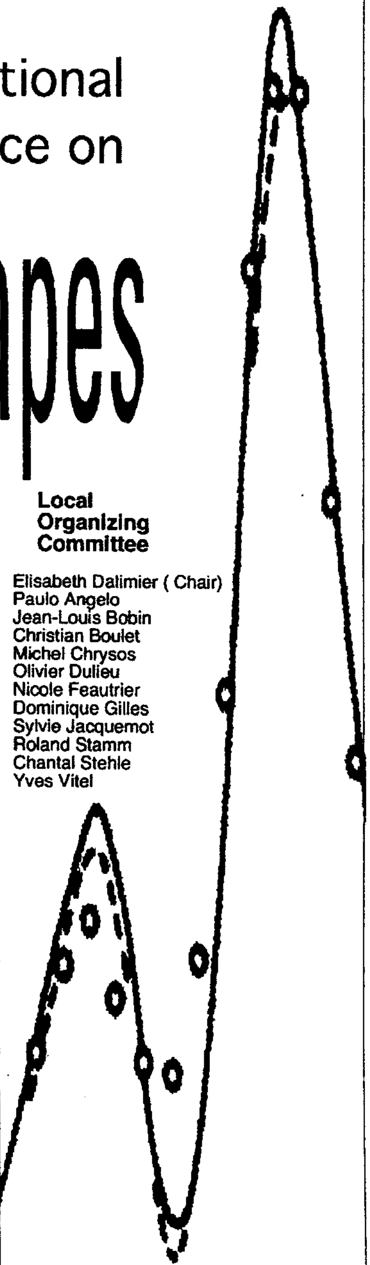

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B21 - The Complex Structure of the MgII λλ 2795.523, 2802.698 A Regions of 64 Be stars

E. Lyratzi[1], E. Danezis[1], L. Popovic[2], M. Dimitrijevic[2], D. Nikolaidis[1], A. Soulikias[1]
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In this paper we present a statistical study of the UV MgII resonance lines in 64 Be stars' spectra. We used the method proposed by Danezis et al. (2003). With this method we can study the velocity fields of the complex atmospherical regions of MgII resonance lines λλ 2795.523, 2802.698 A, which present SACs or DACs. We calculate the apparent rotation (V_{rot}) and radial velocities (V_{exp}) of these density regions, as well as their ς value, which is an expression of the optical depth. We found that there exist three levels of rotation velocity with the mean values of 143 km/s, 60 km/s and 31 km/s. The respective mean values of the apparent radial velocity are -19 km/s, -13 km/s and -2 km/s. We also present the relation among these parameters and their evolution with the spectral subtype.

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B22 - The Complex Structure of the SiIV λλ 1393.73, 1402.73 A Regions of 57 BeV Stars

E. Lyratzi[1], E. Danezis[1], L. Popovic[2], M. Dimitrijevic[2], D. Nikolaidis[1], A. Soulikias[1],
A. Antoniou[1] & M. Stathopoulou[1]

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In this paper we present a statistical study of the UV SiIV resonance lines in 57 BeV stars' spectra. We used the method proposed by Danezis et al. (2003). With this method we can study the velocity fields of the complex atmospherical regions of SiIV resonance lines λλ 1393.73, 1402.73 A, which present SACs or DACs. We calculate the apparent rotation (V_{rot}) and radial velocities (V_{exp}) of these density regions, as well as their ξ value, which is an expression of the optical depth. We found that there exist five levels of rotation velocity with the mean values of 830 km/s, 492 km/s, 285km/s, 137 km/s and 51 km/s. The values of the apparent radial velocity of all the SACs lie in the range between -306 km/s and +194 km/s. We also present the relation among these parameters and their evolution with the spectral subtype.

1. Danezis E., Nikolaidis D., Lyratzi V., Stathopoulou M., Theodossiou E., Kosionidis A., Drakopoulos C., Christou G. and Koutsouris P.: "A new model for the structure of the DACs regions in the Oe and Be stellar atmospheres", 2003, *Astrophysics and Space Science*, 284, 1119

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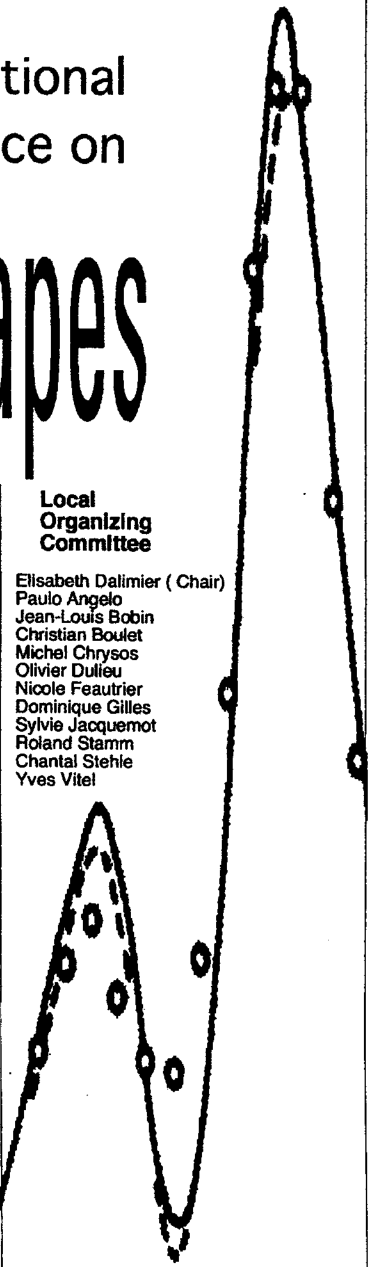

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B23 - Collisions with Charged Particles for Stellar Four Times Ionized Silicon Line Shapes

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The aim of this communication is twofold. First we have computed Si V Stark broadening parameters within the semiclassical formalism [1,2] by using oscillator strengths from SUPERSTRUCTURE code in order to provide new Stark broadening data of astrophysical interest. Additionally, we have performed the same calculations using for needed atomic data the Coulomb approximation method [3], in order to estimate the error introduced in the Stark broadening parameters due to uncertainties of oscillator strength values due to the use of the Coulomb approximation.

The energy levels of Si V are calculated using the general atomic structure code SUPERSTRUCTURE developed at the University College in London [4]. The wave functions are determined by diagonalization of the non-relativistic Hamiltonian using orbitals calculated in a scaled Thomas-Fermi-Dirac-Amaldi (TFDA) potential. The scaling parameters have been obtained by a self-consistent energy minimization procedure on all term energies of the eleven configurations $1s^22s^22p^6$, $2s^22p^53l$, $2s2p^63l$ and $2s^22p^54l$ (l less or equal to n-1). The relativistic corrections: spin-orbit, mass, Darwin and one-body, are introduced according to the Breit-Pauli approach [5] in intermediate coupling LSJ. By combining the SUPERSTRUCTURE code, calculating energy levels and oscillator strengths, and the code for semiclassical perturbation Stark broadening calculations, we obtained possibility to calculate *ab initio* Stark broadening parameters.

With the obtained energy levels and oscillator strengths, Stark broadening widths and shifts, for 16 multiplets of the four times ionized Silicon (Si V) lines have been calculated using the semiclassical perturbation theory [1,2], innovated and optimized several times. The obtained results will be published elsewhere [6]. They are obtained for temperatures from 50,000 K to 500,000 K and electron density of 10^{17} cm^{-3}. In order to complete Stark broadening data for most important charged perturbers in stellar atmospheres, Stark broadening parameters for proton, He II, and Si II impact line widths and shifts are calculated also.

By using atomic energy levels obtained by SUPERSTRUCTURE code, we have calculated also oscillator strengths with the help of the Coulomb approximation with quantum defect of Bates and Damgaard [3]. If we compare results for Stark widths obtained with oscillator strengths calculated with SUPERSTRUCTURE and by using Bates and Damgaard approximation, the average ratio of Stark widths with Coulomb and SUPERSTRUCTURE oscillator strengths is 1.09 for T = 50 000 K and 1.10 for 500 000 K. Since, in Stark broadening calculations we use a set of atomic data where a particular oscillator strength value is not always critical, obtained result confirm that the Bates and Daamgard approximation may be useful for Stark broadening calculations in the case of ions as Si V, when more reliable data are not available.

We also compared Stark and Doppler widths of selected spectral lines for various hot stellar atmospheres and white dwarfs. Compared to the Doppler broadening, influence of Stark broadening mechanism is more important for deeper atmospheric layers and for larger values of log *g*. Stark broadening does not depend on turbulent velocity for the considered stellar model of standard main sequence hot star of A0 spectral type. Influence of the Stark widths for standard models of DA and DB white dwarfs has been also discussed.

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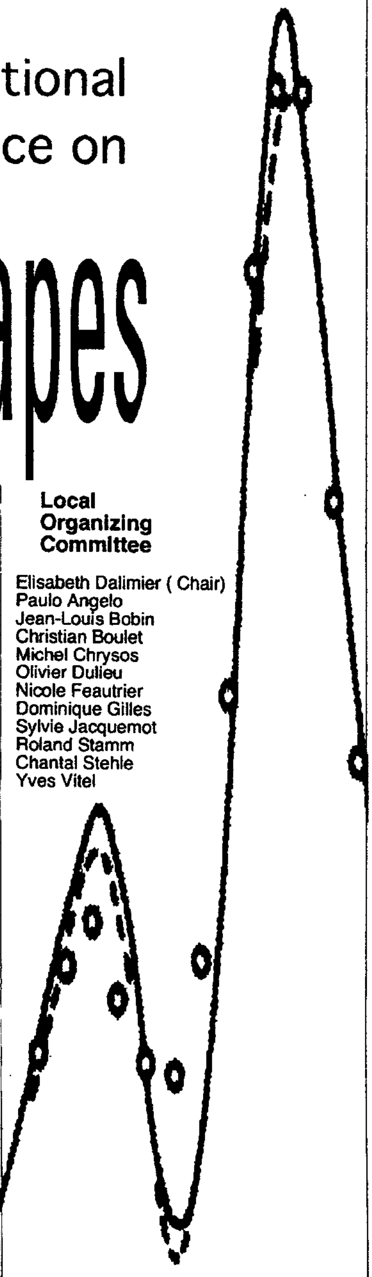

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A2 - Semi-Classical and Modified Semi-Empirical Impact Stark Broadening Calculations of Singly-Ionized Oxygen Spectral Lines

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Using the semi-classical impact perturbation theory including both dipole and quadrupole terms in the expression of electrostatic interaction between the optical electron and the perturber [1-3], we calculated widths and shifts of singly ionized oxygen (O II) spectral lines and compared with experimental results and those calculated by Griem [4]. Energy levels and oscillator strengths have been taken from TOPbase [5]. Mean radius and mean square radius have been calculated within hydrogenic approximation using the effective quantum numbers n_i^* obtained from TOPbase.

The impact approximation was checked for each case using the condition of validity by Ben Nessib (the collision volume must be very small compared to the inverse of the perturber density) [6].

The ionic perturbers depend on experiments and we add the proton-impact Stark widths for possible astrophysical applications.

We also calculated modified semi-empirical widths using the formalism of Dimitrijevic and Konjevic [7], where the mean square radius is expressed in terms of the oscillator strengths for the contribution of the collisional transitions with Dn=0 and hydrogenic approximation is used for Dn≠0.

Inside the same multiplet, widths and shifts of various lines are determined by scaling multiplet values method of Popovic [8].

In this work the calculation of widths and shifts of some lines are obtained for the first time [9,10].

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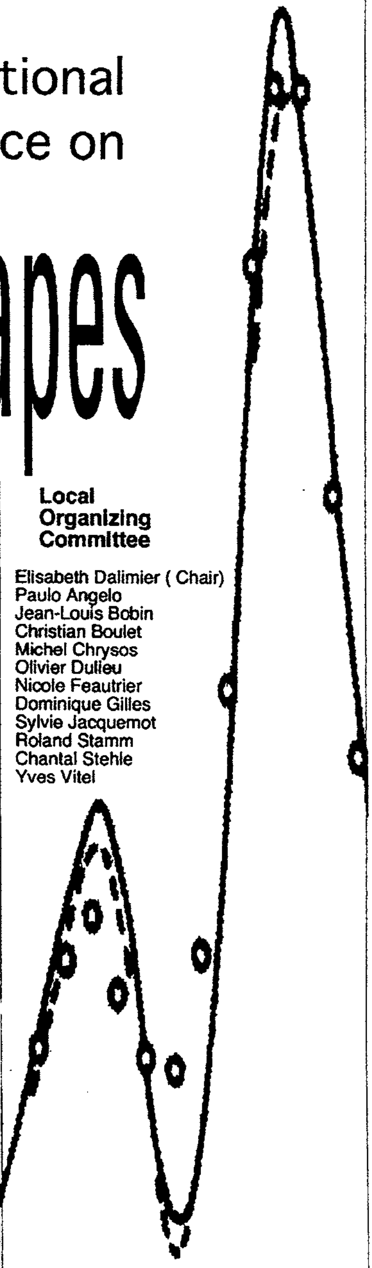

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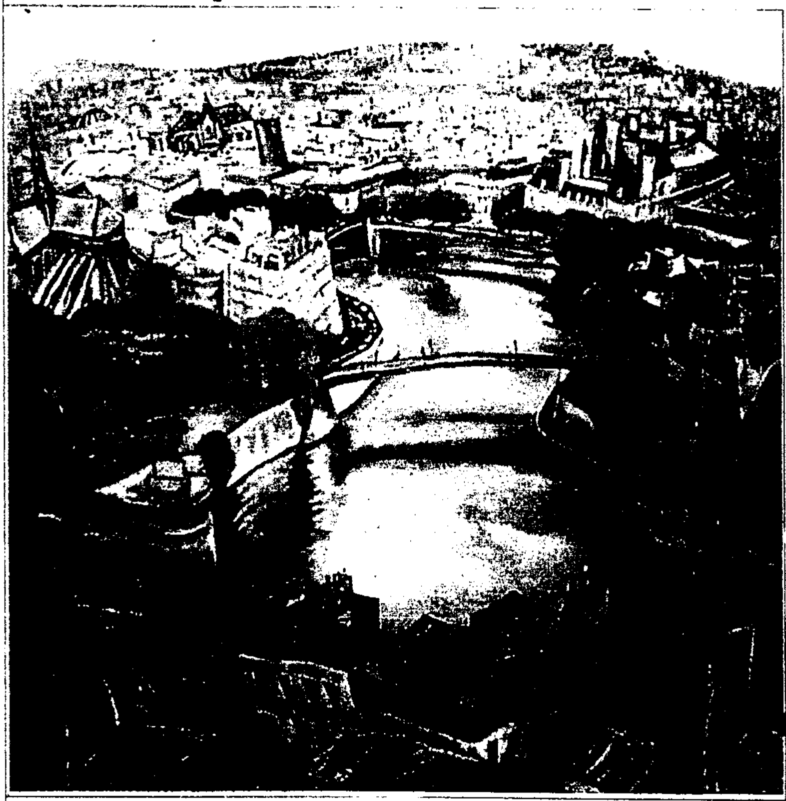

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A5 - Stark Broadening of Spectral Line Shapes
(on the French-Serbian Collaboration)

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Abstract: The importance of Stark broadening research is discussed. Then, a short review of French-Serbian collaboration on the theoretical investigations (within the frame of the semiclassical perturbation approach) of Stark broadening of nonhydrogenic spectral line shapes is presented, with a bibliography of results published in international journals.

Key words: Stark broadening, Line profiles, Plasmas, Atomic data

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Editors:

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ON THE STARK BROADENING OF NEUTRAL RUBIDIUM SPECTRAL LINES

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1. INTRODUCTION

Stark-broadening parameters of Rb I are of interest for laboratory plasma investigation and diagnostic [1-3] as well as for Solar and stellar spectroscopy [4,5]. By using the semiclassical-perturbation formalism, [6,7] we have calculated electron-, proton-, and ionized argon-impact line widths and shifts for 24 Rb I multiplets. A summary of the formalism is given in Ref. 8. The obtained results for Stark broadening parameters will be published elsewhere [9,10]. Here, we discuss the results for Rb I, along with a comparison with experimental data and other theoretical results.

2. RESULTS AND DISCUSSION

Energy levels for Rb I lines have been taken from Ref. 11. Oscillator strengths have been calculated by using the method of Bates and Damgaard [12,13]. For higher levels, the method described in Ref. 14 has been used. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton- and ionized-argon impacts have been calculated, for astrophysical, and laboratory plasma research respectively. As a sample of obtained results, the data for seven most important multiplets are shown in Table 1 for a perturber density of 10^{15}cm^{-3} and temperatures T = 2,500 - 50,000 K. We also specify a parameter **c** which, when it is divided by the corresponding electron-impact full width at half maximum, gives an estimate for the maximum perturber density for which the line may be treated as isolated. For each value given in Table 1, the collision volume (V) multiplied by the perturber density (N) is much less than one and the impact approximation is valid. Values for $0.1 < NV \leq 0.5$ are denoted by an asterisk. When the impact approximation is not valid, the ion-broadening contribution may be estimated by using quasistatic estimations [15,16]. The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

Table 1. This table shows electron-, proton-, and Ar II-impact broadening parameters for Rb I lines, for perturber densities of 10^{15} cm^{-3} and temperatures from 2,500 to 50,000 K. Transitions and averaged wavelengths for the multiplet (in [Å]) are also given. By using **c** [see Eq. (5) of Ref.8], we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used. The asterisk (*) identifies cases for which the collision volume (V) multiplied by the perturber density (N) (the condition for validity of the impact approximation [6,7] is NV $\ll$ 1) lies between 0.1 and 0.5.

Perturber density = $1 \cdot 10^{15}$ cm^{-3}							
Perturbers are		Electrons		Protons		Ionized argon	
Transition	T[K]	Width [Ð]	Shift [Ð]	Width [Ð]	Shift [Å]	Width [Å]	Shift [Å]
4d-5p 15156.1 Å c = 0.10E+20	2500	0.367E-01	0.123E-01	0.123E-02	0.324E-01	0.121E-01	0.184E-02
	5000	0.403E-01	0.151E-01	0.123E-02	0.366E-01	0.121E-01	0.129E-02
	10000	0.479E-01	0.149E-01	0.124E-02	0.413E-01	0.121E-01	0.237E-02
	20000	0.616E-01	0.143E-01	0.126E-02	0.465E-01	0.122E-01	0.267E-02
	30000	0.712E-01	0.123E-01	0.127E-02	0.498E-01	0.122E-01	0.287E-02
	50000	0.872E-01	0.102E-01	0.128E-02	0.542E-01	0.122E-01	0.313E-02
4d-6p 22634.0 Å c = 0.99E+19	2500	0.429	0.285	0.134	0.730E-01	*0.118	*0.400E-01
	5000	0.492	0.343	0.140	0.8[illegible]1E-01	*0.121	*0.470E-01
	10000	0.551	0.360	0.147	0.958E-01	0.123	0.543E-01
	20000	0.629	0.345	0.156	0.109	0.126	0.620E-01
	30000	0.682	0.303	0.162	0.117	0.129	0.668E-01
	50000	0.768	0.257	0.171	0.128	0.132	0.733E-01
4d-7p 11576.1 Å c = 0.11E+19	2500	0.403	0.280	*0.122	*0.668E-01		
	5000	0.461	0.334	0.129	0.789E-01		
	10000	0.513	0.328	0.137	0.914E-01	*0.111	*0.508E-01
	20000	0.573	0.303	0.146	0.105	*0.115	0.590E-01
	30000	0.620	0.272	0.152	0.113	*0.117	*0.639E-01
	50000	0.682	0.219	0.124	0.124	*0.121	*0.705E-01
4d-8p 9529.3 Å c = 0.39E+18	2500	0.708	0.484	*0.200	*0.106		
	5000	0.797	0.560	*0.214	*0.131		
	10000	0.885	0.563	*0.229	*0.155		
	20000	0.958	0.450	*0.246	*0.179		
	30000	1.07	0.374	0.257	0.194		
	50000	1.16	0.298	0.273	0.214		
5s-5p 7838.7 Å c = 0.41E+19	2500	0.722E-02	0.448E-02	0.352E-02	0.118E-02	0.314E-02	0.667E-03
	5000	0.783E-02	0.535E-02	0.330E-02	0.133E-02	0.316E-02	0.760E-03
	10000	0.877E-02	0.539E-02	0.336E-02	0.150E-02	0.318E-02	0.863E-03
	20000	0.109E-01	0.463E-02	0.344E-02	0.169E-02	0.320E-02	0.975E-03
	30000	0.126E-01	0.380E-02	0.349E-02	0.181E-02	0.321E-02	0.104E-02
	50000	0.154E-01	0.299E-02	0.358E-02	0.198E-02	0.324E-02	0.114E-02
5s-6p 4206.4 Å c = 0.34E+18	2500	0.141E-01	0.981E-02	0.508E-02	0.255E-02	*0.458E-02	*0.140E-02
	5000	0.162E-01	0.115E-01	0.527E-02	0.249E-02	*0.467E-02	*0.164E-02
	10000	0.182E-01	0.125E-01	0.550E-02	0.335E-02	0.476E-02	0.190E-02
	20000	0.206E-01	0.121E-01	0.579E-02	0.380E-02	0.486E-02	0.217E-02
	30000	0.222E-01	0.106E-01	0.599E-02	0.408E-02	0.492E-02	0.233E-02
	50000	0.248E-01	0.897E-02	0.626E-02	0.446E-02	0.502E-02	0.256E-02
5s-7p 3589.2 Å c = 0.11E+18	2500	0.370E-01	0.256E-01	*0.117E-01	*0.624E-02		
	5000	0.424E-01	0.311E-01	0.123E-01	0.737E-02		
	10000	0.472E-01	0.307E-01	0.131E-01	0.853E-02	*0.107E-01	*0.474E-02
	20000	0.527E-01	0.281E-01	0.139E-01	0.976E-02	*0.111E-01	*0.550E-02
	30000	0.568E-01	0.242E-01	0.145E-01	0.105E-01	*0.113E-01	*0.597E-02
	50000	0.623E-01	0.205E-01	0.153E-01	0.115E-01	*0.116E-01	*0.658E-02

In Tables 2 and 3, the present results with Ar II -impact contribution included,are compared with experimental data [1,2], with other semiclassical [3], and with semiempirical calculations [1,2]. In all cases we added to Stark broadening parameters due to electron-impacts, our results for Ar II - impact broadening. We see that the agreement between experimental and theoretical values is particularly good for shifts.

Table 2. Comparison between the experimental Stark full halfwidths of Rb I lines (Wm - Purić et al (1977)[2]) within the 5s^{2}S - 5p^{2}P^o multiplet with different calculations. Semiclassical calculations: WDSB-present results; WfMB-present results with the oscillator strengths taken from table 4 (values denoted as RHF+CP) in Ref.17; WfW-present results with oscillator strengths taken from Ref. 18; WSC - Dimitrijević and Konjević (1983) [3] .(by using semiclassical theory of Griem (1974) [13]). Semiempirical calculations: WSE - Purić et al (1977) [2] (by using Griem's semiempirical method [19]). The electron density N is equal to 10^{17}cm^{-3} .

λ [Å]	T[K]	Wm[Å]	WDSB[Å]	WDK[Å]	WSE[Å]	WfMB[Å]	WfW[Å]
7800.2	15000	1.66	1.31	1.60	1.91	1.09	1.08
	17500	1.70	1.35	1.68	1.97	1.13	1.13
	20800	1.76	1.42	1.77	2.08	1.18	1.18
	26000	1.92	1.51	1.88	2.16	1.25	1.26
7947.6	15000	1.82	1.31	1.60	1.91	1.09	1.08
	17500	1.92	1.35	1.68	1.97	1.13	1.13
	20800	2.00	1.42	1.77	2.08	1.18	1.18
	26000	2.20	1.51	1.88	2.16	1.25	1.26

Table 3. As in Table 2 but for the shift (d).

λ [Å]	T[K]	dm[Å]	dDSB[Å]	dDK[Å]	dfMB[Å]	dfW[Å]
7800.2	15000	0.52	0.59	0.48	-0.31	-0.23
	17500	0.50	0.57	0.48	-0.32	-0.25
	20800	0.47	0.54	0.48	-0.34	-0.26
	26000	0.51	0.50	0.47	-0.35	-0.28
7947.6	15000	0.55	0.59	0.48	-0.31	-0.23
	17500	0.53	0.57	0.48	-0.32	-0.25
	20800	0.50	0.54	0.48	-0.34	-0.26
	26000	0.45	0.50	0.47	-0.35	-0.28

In order to see the influence of oscillator strength values to results, calculations have been repeated with oscillator strengths calculated by using relativistic single- configuration Hartree-Fock method with allowance for core polarization, which have been taken from Ref. 17, and with oscillator strengths from Ref. 18, where allowance for configuration mixing and for spin-orbit interaction has been made. One can see that the agreement with experiment is now worse for Stark widths and for shifts even the sign is different. If we use better oscillator strength values for particular transition, the final result is not always better since for the calculations we need a homogeneous set of oscillator strength values. This homogenity might be disturbed if we use a mix of values from different sources.

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STARK BROADENING OF Al XI AND Si XII SPECTRAL LINES

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1. INTRODUCTION

Due to its theoretical simplicity (one optical electron), Stark broadening parameters for spectral lines for ions within the lithium isoelectronic sequence have particular importance for the investigation of regularities and systematic trends. Results of such investigations are of interest for acquisition of new data by interpolation and for critical evaluation of existing experimental and theoretical data, particularly in astrophysics. Moreover, the astrophysical importance of multiply charged ion lines is increasing due to the developpement of UV astronomy from space and owing to the developpement of researches on the physics of stellar interiors (Seaton, 1987).

In order to investigate the behavior of Stark broadening parameters along an isoelectronic sequence as far as posible without the significant influence of relativistic effects, we have calculated electron-, proton-, and He III- impact line widths and shifts for 7 Al XI and 9 Si XII multiplets, as the continuation of our previous calculations of Stark broadening parameters for C IV, N V, O VI, F VII, Ne VIII, Na IX ions within the lithium isoelecttronic sequence, as well as for other multiply charged ions (Dimitrijević et al 1991a,b; Dimitrijević and Sahal-Brechot 1992a-c; 1993a-c; 1994a). The evaluation of Stark broadening parameters has been performed by using the semiclassical - perturbation formalism (Sahal-Bréchot 1969ab). A summary of the formalism is given in Dimitrijević and Sahal-Bréchot (1991). Stark broadening parameters for Al XI and Si XII lines will be published elsewhere (Dimitrijević and Sahal-Brechot 1994b). Here, we discuss the obtained results as well as the Stark broadening parameter behaviour within the lithium isoelectronic sequence.

2. RESULTS AND DISCUSSION

Energy levels for Al XI and Si XII lines have been taken from Martin and Zalubas (1979, 1983) respectively. Oscillator strengths have been calculated by using the method of Bates and Damgaard (1949) and the tables of Oertel and Shomo (1968). For higher levels, the method described by Van Regemorter et al. (1979) has been used. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and He II- impacts have been calculated.

Our results for 7 Al XI and 9 Si XII multiplets for perturber densities 10^{18} - 10^{23} cm^{-3} and temperatures T = 500,000 - 4,000,000 K, will be published elsewhere (Dimitrijević and Sahal-Brechot 1994b).

In Figs. 1 and 2, the behavior of electron-, and proton-impact widths and shifts within the lithium isoelectronic sequence is shown. We can see that the behavior is regular. This fact might be of interest for the interpolation of new data and for critical selection of existing results.

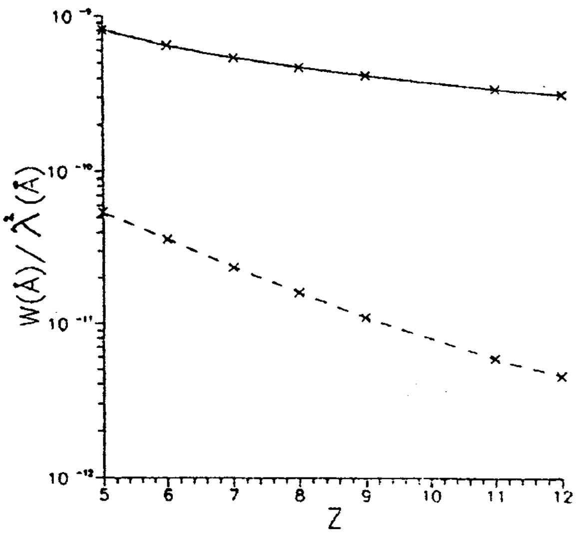

Fig.1 The behavior of W(FWHM)[Å]/(λ[Å])^2 for(- ------) electron- and (-----) proton-impact along the lithium isoelectronic sequence. With Z is denoted the residual charge as "seen" by the optical electron (Z=1 for neutrals, 2 for singly charged ions etc). The considered transition is 2s-2p, electron density 10^{17} cm^{-3} and temperature 500,000 K.

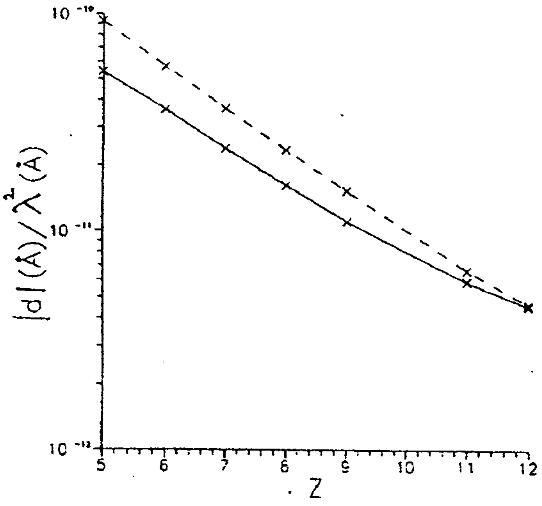

Fig.2 Same as in Fig. 1 but for the shift.

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Using line broadening to determine the electron density in an argon surface-wave discharge at atmospheric pressure

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INTRODUCTION

Pressure broadening of spectral lines is important for the diagnostics and modeling of laboratory plasmas, and for many purposes in astrophysics, as for example opacity calculations, abundance determination and analysis and synthesis of stellar spectra. Neutral atom broadening is more important for cooler stars like our Sun and Stark broadening for hot stars like A-type stars and in particular for DO and DB white dwarfs..

It is well known that argon is one of the most widely used gases in various fields of science and technology. On the other hand, with the development of space-borne spectroscopy, the importance of atomic data, including line broadening parameters for trace elements like argon [1], is increasing. Spectral lines within the optical spectral range are of particular interest.

In this work, different line broadening models are applied to three Ar I spectral lines to evaluate the electron density in a surface-wave discharge at atmospheric pressure. This method is useful in cases where the classical methods using hydrogen lines for electron density diagnostic cannot be applied.

THEORETICAL CALCULATIONS

Under atmospheric pressure conditions, the broadening mechanisms of spectral lines are: Stark broadening (due to collisions with charged particles), neutral atom collision broadening (due to collisions with neutral atoms), Doppler broadening and natural broadening. Natural broadening is negligible in comparison with other broadenings and broadening due to self-absorption can be avoided by a proper choice of the spectral lines. For both pressure-induced mechanisms of line broadening (Stark broadening and neutral atom broadening), the impact approximation theory has been applied.

Stark broadening

In this work, the Stark broadening has been calculated using Sahal-Bréchot theory [2, 3]. Within the semi-classical perturbation formalism, used in this theory, the full half width (W) of an isolated line originating from the transition between the initial level i and the final level f is expressed as:

$$W = 2n_e \int_0^{\infty} v f(v) dv [\Sigma_{i' \neq i} \sigma_{ii'}(v) + \Sigma_{f' \neq f} \sigma_{ff'}(v) + \sigma_{el}] \tag{1}$$

where i' and f' are perturbing levels, n_e and v are the electron density and the velocity of perturbers respectively, and $f(v)$ is the Maxwellian distribution of electron velocities. The inelastic collisional cross sections $\sigma_{ii'}(v)$ (respectively $\sigma_{ff'}(v)$) and the corresponding elastic collision contribution σ_{el} to the W are described in detail in [2, 3].

Neutral atom collision broadening

The line broadening by the neutral atoms has been treated using the semi-classical theory calling for the impact approximation where the full width at half intensity maximum γ is given by:

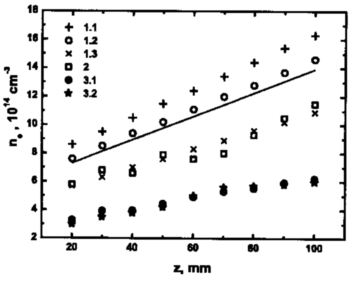

FIGURE 1. Axial variation (z - the position on the axis) of the electron density (n_e) obtained from different Ar I lines. Results obtained using the theory of Sahal-Bréchot for Stark broadening [2, 3] and the potential of Kaulakys [4] for neutral atom impact broadening: 1.1 - Ar I 522 nm; 1.2 - Ar I 549 nm; 1.3 - Ar I 603 nm. Results obtained with Stark broadening data of Griem [6] and van der Waals potential: 2 - Ar I 549 nm. Results obtained with data for Stark broadening of Hβ line from Griem [6] and Gigosos [7]: 3.1 - Hβ (Griem); 3.2 - Hβ (Gigosos).

$$\gamma = 2N < \sigma' v > = \beta N \tag{2}$$

where N is the perturber density, σ' is the effective cross section for the impact broadening of the line and β is the broadening coefficient. Here the symbols <...> denote the (thermal) average over a Maxwellian distribution of the relative velocities of the interacting atoms. Kaulakys potential [4] for the interaction between an emitting atom and rare-gas atoms has been used. This potential accounts for the polarization attractions between the emitter and perturber and for the short-range interactions between excited electrons of the emitter and perturber. The contributions from the polarization attraction of this potential are given by:

$$V\left(\vec{R},\vec{r}\right) = V_c\left(\vec{R}\right) + V_{ce}\left(\vec{R},\vec{r}\right) + V_e\left(\vec{r}-\vec{R}\right), |\vec{R}-\vec{r}| > r_0 \tag{3}$$

where $\vec{R}$ is the distance between the interacting atoms, $\vec{r}$ is the location of the excited electron and r_0 is the distance of the short-range interaction. The short-range interaction is approximated by the Fermi pseudo-potential:

$$V_e\left(\vec{r}-\vec{R}\right) = 2\pi L\delta\left(\vec{r}-\vec{R}\right) \tag{4}$$

where L is the scattering length.

RESULTS

Results for the axial variation of the electron density of surface-wave tubular discharges from the line broadening of three argon neutral lines are presented on the same figure. The examined argon lines Ar I 522.1, 549.6 and 603.2 nm are from the spectral series 3p^{5}nd-3p^{5}4p. The results are compared with those obtained in [5] from Ar I 549.6 nm and with the electron density values from the Stark broadening of hydrogen line H$_\beta$, using Griem's theory [6] and using Gigosos et al. model [7]. The calculations presented are of interest for determining the electron density of, for example, surface-wave discharges at atmospheric pressure using the line broadening of the carrier gas itself, therefore avoiding the use of hydrogenic spectral lines that imply perturbing the discharge to be diagnosed.

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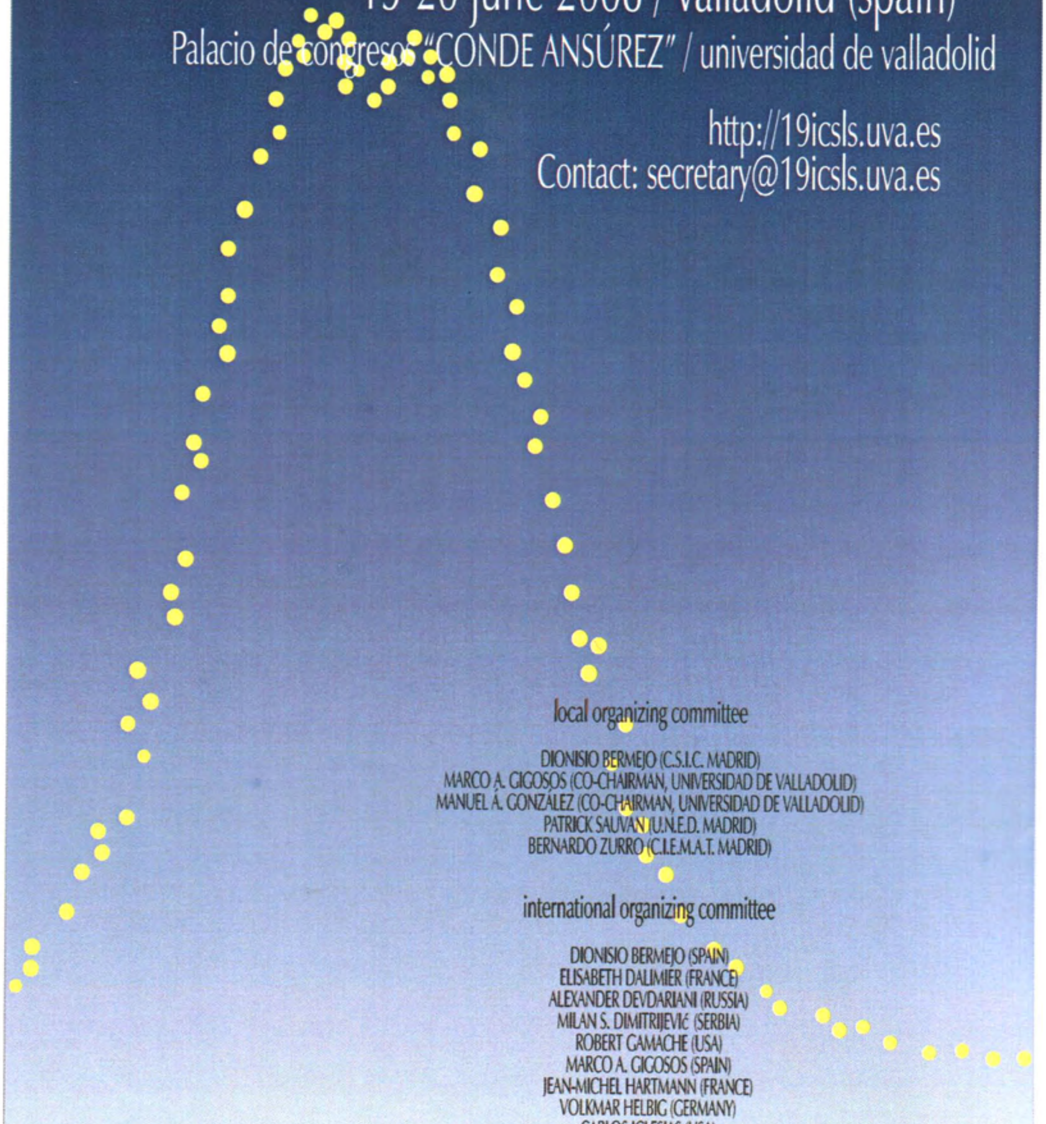

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Gas Temperature Determination in Argon-Helium Plasma at Atmospheric Pressure using van der Waals Broadening

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INTRODUCTION

In the last years, a common characteristic of most of the technological applications of plasmas is that they are a gas mixture. When more than one kind of gas is present in the discharge, the complexity of experimental determination of plasma parameters by spectroscopic techniques increases. It is due to the existence of different types of perturbers in the plasma gas, which have influence on the spectral line profiles and van der Waals broadening is a function of the reduced mass of colliding atoms. Studies of such influences are important for the application of spectroscopic techniques in the diagnostics of plasmas generated with gas mixtures.

In this work, the use of the van der Waals broadening of the atomic lines to determine the gas temperature in Ar-He plasmas, taking into account both argon and helium atoms as perturbers, has been analyzed. The values of the gas temperature inferred from this broadening have been compared with the ones obtained from the spectra emitted by the OH molecular species in the discharges.

Theoretically, any spectral line could be used for the determination of the plasma gas temperature from its van der Waals broadening. However, experimental studies carried out by several authors (see Refs. cited in [1]) have stated that only a few lines can be used for this purpose. First of all, the separation of the van der Waals broadening from the whole width of the spectral profile, needs a deconvolution process. Also, the theory does not describe equally good the van der Waals broadening for each spectral line and for each kind of perturbers, so that the corresponding investigations in order to find the most convenient lines for this purpose are of interest.

In a surface wave plasma generated with pure Ar, in [2] is studied the contribution of the Stark broadening to the Lorentzian width for Ar lines belonging to the $nd - 4p$ transitions ($4 \leq n \leq 7$). The procedure used to separate both Lorentzian and Gaussian parts by these authors was the same as one used in the present work. Their results showed that Stark broadening can be considered negligible for the 737.2 nm ($n = 4$) line and very small for the 603.2 nm ($n = 5$). Consequently, they considered that the Lorentzian width of these lines was mainly due to the van der Waals effect and the gas temperature obtained from 603.2 nm was approximately equal to the one obtained from OH radical band (approximately 1500 K) in this case.

In [3] is proposed a method to measure the gas temperature T_g from atomic lines whose Stark broadening is comparable with the van der Waals one. T_g was obtained from the origin ordinate corresponding to the Lorentzian width for zero electron density which could be considered approximately equal to van de Waals line width. For this study the best argon atomic lines for the gas temperature T_g calculation in an argon microwave plasma at atmospheric pressure were 603.2 nm, 549.6 nm and 522.1 nm. The values obtained from this method were between 1100 and 1200 K. On the other hand, in [4] was studied the Stark broadening of the 425.9 nm line. By extrapolating the results in [4] to their experimental conditions, Yubero *et al.* [3] obtained that the van der Waals width value of the above mentioned line was about 90% of the total Lorentzian width and the gas temperature from the van der Waals broadening of this line was equal to 1380 K. Consequently with all these results, the use of 425.9, 603.2, 549.6 and 522.1 nm lines to measure the gas temperature in plasmas generated with Ar-He mixtures was considered in the present work.

GAS TEMPERATURE DETERMINATION IN AR-HE MIXTURE DISCHARGE

The experimental procedure is described in detail in [1]. The spectra for these lines were registered in different conditions of Ar-He mixtures, observing a significant decrease of the intensities of the Ar atomic lines when He is added to the plasma gas. An analysis of the profiles of these lines was carried out in the more extreme condition which corresponded, in our case, to a 30% of He in the mixture. We found that with the increase of the upper level of the transition a high dispersion in the fit of the 549.6 nm ($4p - 6d$ transition) and 522.1 nm ($4p - 7d$ transition) line profiles to a Voigt function appears. Thus, only the 425.9 nm ($4s - 5p$) and 603.2 nm ($4p - 5d$) lines have been considered for this study.

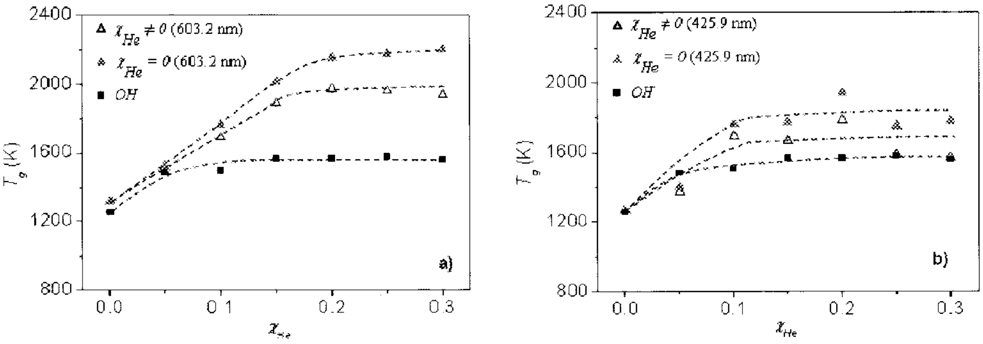

FIGURE 1. Gas temperature calculated using the (0 – 0) 309 nm rovibrational band of the OH radical and the 603.2 nm (a) and 425.9 nm (b) atomic argon lines taking into account (hollow triangle) and neglecting (full triangle) the contribution of He to the van der Waals broadening

The T_g values obtained from the van der Waals of the 603.2 and 425.9 nm lines appear depicted in Figs.1a and 1b, respectively. These temperature values have been calculated by using equations derived in [1]. In the case of an Ar-He mixed gas discharge, full width at half maximum (FWHM) provoked by van der Waals broadening (w_W) is given by the following equations

$$w_W(425.9\,\mathrm{nm}) = \chi_{Ar}\frac{1.479}{T_g^{0.7}} + \chi_{He}\frac{1.059}{T_g^{0.7}} \tag{1}$$

$$w_W(603.2\,\mathrm{nm}) = \chi_{Ar}\frac{4.217}{T_g^{0.7}} + \chi_{He}\frac{3.019}{T_g^{0.7}} \tag{2}$$

where χ_{Ar} and χ_{He} are molar fractions of the constituting gases, argon and helium. Also, the values obtained from OH radical band have been represented. In Fig. 1 one observes that the T_g calculated from w_W are a slightly higher that those obtained from OH radical. It is also observed a bigger dispersion in T_g values from w_W of 425.9 nm line than 603.2 nm line because of its smaller Lorentzian width value w_L, which results in higher error in the deconvolution process.

Moreover, to point up that T_g values obtained from OH radical is lower than those obtained from the Lorentzian width of Ar lines for He concentrations obove 5%. This can be due to a lack of sensitivity of the OH radical for temperatures higher than 1600 – 1800 K. This result seems to indicate that for the lines used in this work and under our experimental conditions the lorentzian width of the atomic lines can be considered almost equal to their van der Waals broadenings without inducing large errors in T_g determination. The most important result found in this study is the necessity to taking to account He contribution to the van der Waals broadening for lines used in Ar-He mixtures. This allows us to conclude that the above equations may be used when the van der Waals broadening of the considered argon lines is utilized for measuring the gas temperature in an Ar-He plasma.

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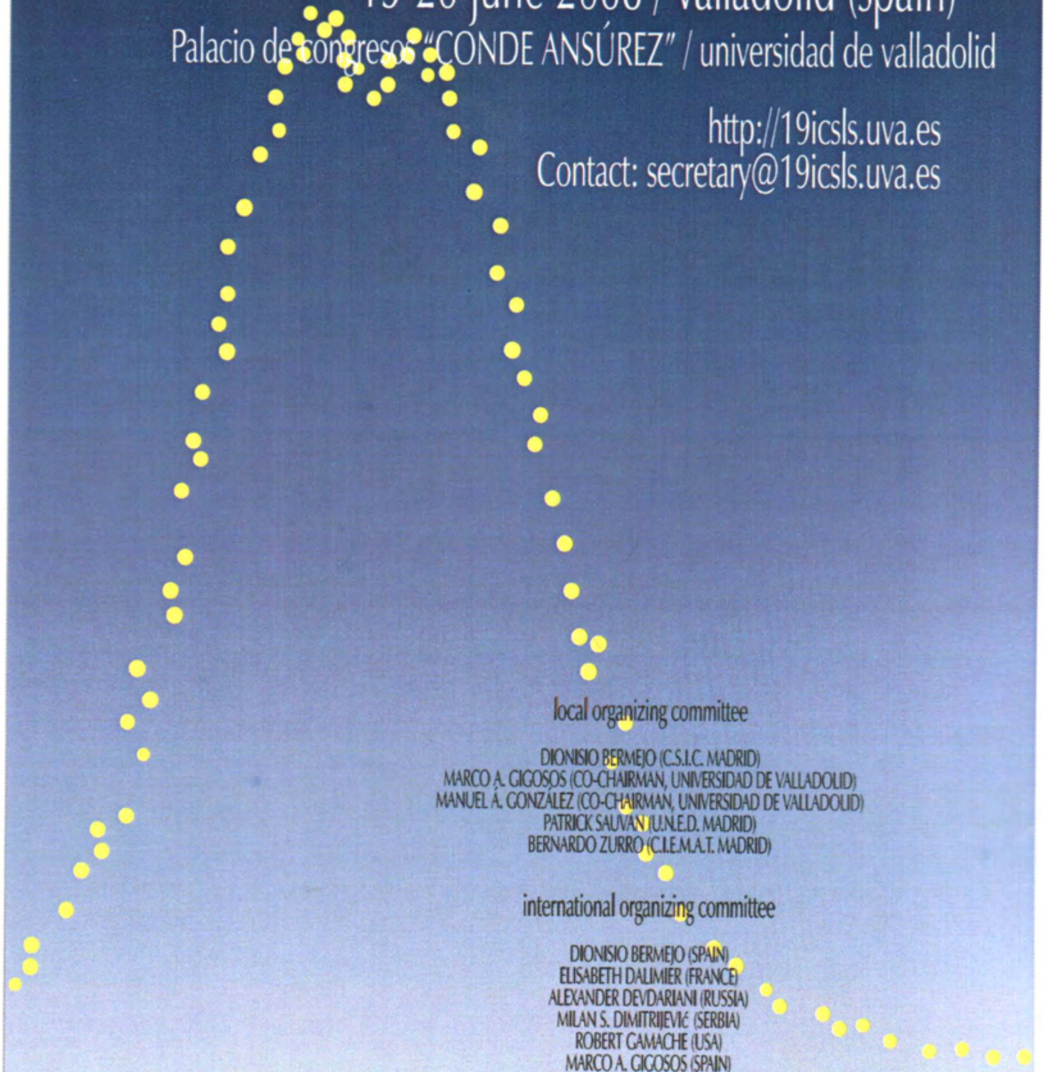

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AXMon (HD 45910) kinematical parameters in the Fe II spectral lines as a function of the excitation potential

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INTRODUCTION

AX Monocerotis (HD 45910=BD+5°, 1267=SAO 13974, $a=6^h\ 27^m\ 52^s$, $\delta=+5°$, $54',1$ (1950), V=6,59-6,88 mag) is a binary system [1], consisting of a B2e III star and a some what fainter K0 III star, with an orbital period of 232.5 days [2, 3] and a variable spectrum [4, 5].

Danezis et al. [6, 7, 8] studied the UV spectrum of the system at phase 0.568 and detected the existence of two satellite components at the violet side and one at the red side of the main absorption lines, indicating that the envelope consists of four independent layers of matter. In the Fe II region they found three levels of values of radial velocities. The first level has values about -10 km/s, the second level has values about -72 km/s and the third level has values about -250 km/s.

Danezis et al. [9, 10] proposed the so called Gaussian-Rotational (GR) model. By applying this model we calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM) and the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines.

In this paper we apply the above mentioned model and calculate the radial, rotational and random velocities for a group of Fe II lines with values of excitation potential between 0.35 to 3.75 eV.

RESULTS AND DISCUSSION

In Figure 1, we give as an example the fit of the λ 2607.086 Å Fe II spectral line. We can see that the observed complex structure can be explained with SACs phenomenon.

In Figure 2 we present the variation of the radial, rotational and the random velocities of the studied group of Fe II lines as a function of the excitation potential. As we can see we detected three levels of radial velocities (up-left). The first level has values about -260 km/s (circle), the second one has values about -125 km/s (open square) and the third one has values about -18 km/s (triangle). These values are in agreement with the respective values found by Danezis et al. [8]. The values of the rotational velocities (Figure 2 up-right) for all SAC are between 20 and 60 km/s. Finally we detected three levels of the random velocities of the ions (Figure 2 down). The first level has values about 115 km/s (open circle), the second one has values about 70 km/s (square) and the third one has values of 35 km/s (triangle).

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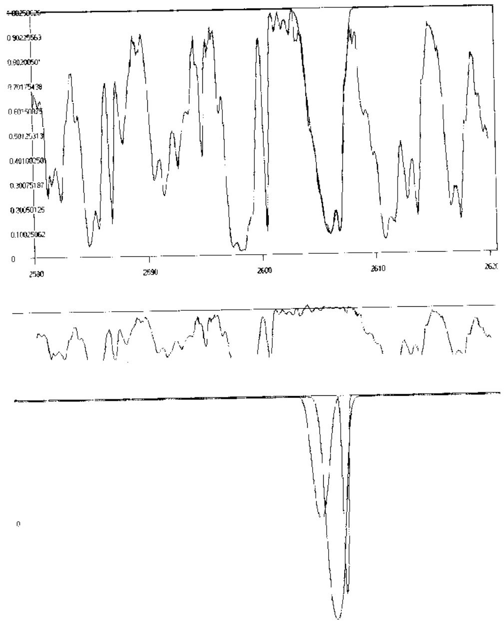

FIGURE 1. Best fit of the λ 2607.086 Å Fe II spectral line. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs.

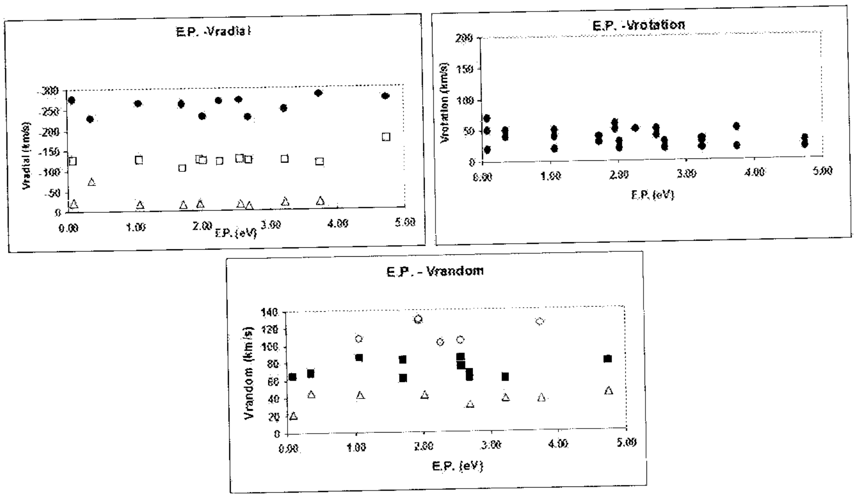

FIGURE 2. Radial (up, left), rotational (up, right) and random velocities (down) of the studied group of Fe II spectral line as a function of the excitation potential.

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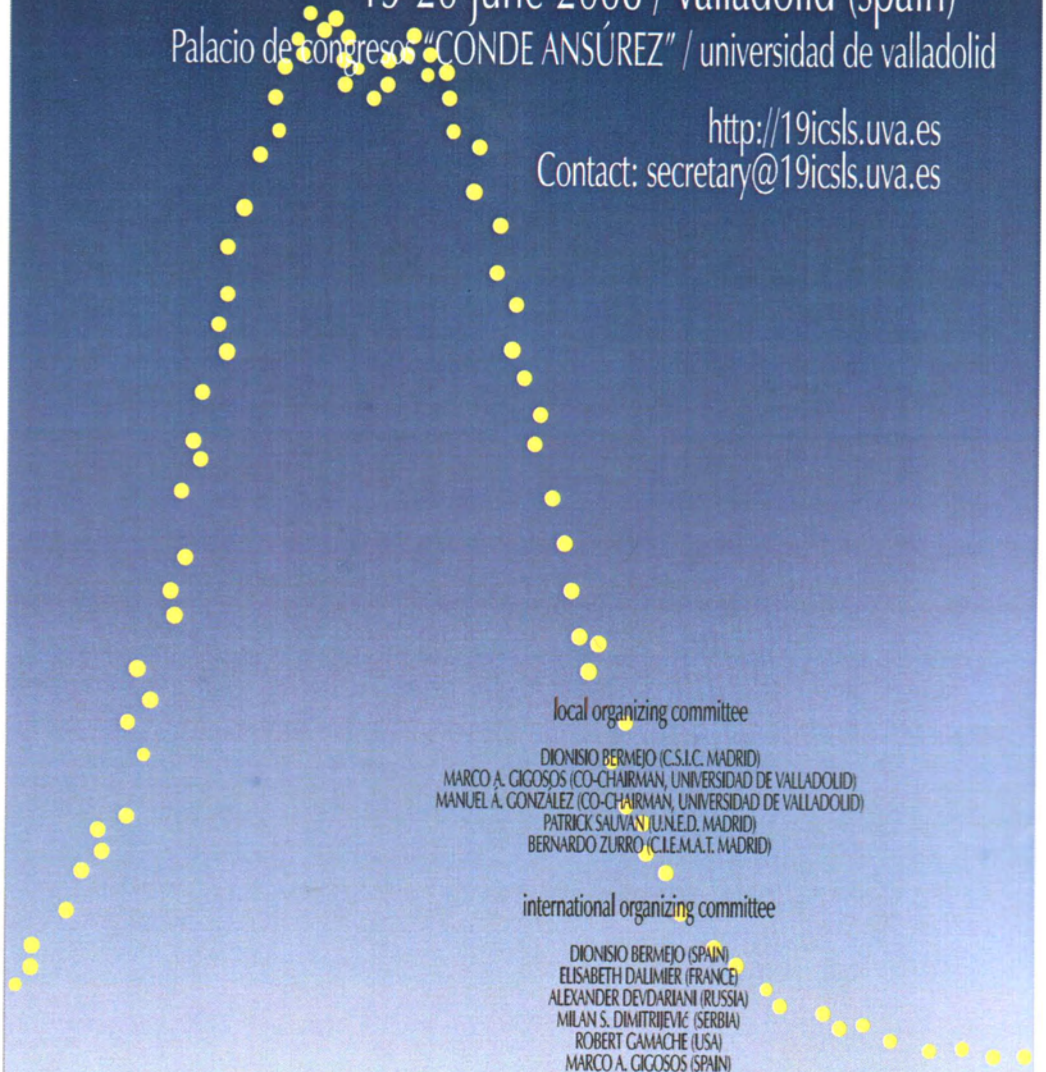

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A study of the structure of different ionization potential regions in the atmosphere of AX Mon (HD 45910)

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INTRODUCTION

AX Monocerotis (HD 45910) is a binary system [1], consisting of a B2e III star and a some what fainter K0 III star, with an orbital period of 232.5 days [2, 3] and a variable spectrum [4, 5].

Danezis et al. [6] presented a study of the variation of radial velocities and of the blue edge width. In this paper, using the Gaussian-Rotational (GR) model [7, 8] we calculate the radial, rotational and random velocities in the Al II (λ 1670.81 Å), Al III ($\lambda\lambda$ 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines of AX Mon, as a function of the ionization potential.

RESULTS AND DISCUSSION

In Figure 1 using the GR model we can see that the complex structure of the $\lambda\lambda$ 1854.722, 1862.782 Å Al III (left) and $\lambda\lambda$ 2795.523, 2802.698 Å absorption and emission Mg II (right) resonance spectral lines can be explained with SACs and DACs phenomenon.

In Figure 2 we present the variation of the radial, rotational and the random velocities in the Al II (λ 1670.81 Å), Al III ($\lambda\lambda$) 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å) C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines as a function of the ionization potential.

As we can see, we detected four levels of radial velocities (up-left). The first level has values about -260 km/s and corresponds to ionization potential larger than 20 eV. The second level has values about -140 km/s, the third one has values about -35 km/s and the fourth one has values about 119 km/s. All these values correspond to ionization potential with values between 0 and 10 eV. The values of the rotational velocities (Figure 2 up-right) are between 150 and 450 km/s and correspond to ionization potential larger than 10 eV. The low values of the rotational velocities (10-50 km/s) correspond to ionization potential with values between 0 and 10 eV. Finally, we also detected four levels of the random velocities of the ions (Figure 2 down). The first level has values about 108 km/s and corresponds to ionization potential larger than 18 eV. The second level has values about 80 km/s, the third one has values about 47 km/s and the fourth one has values about 22 km/s. All these values correspond to ionization potential with values between 0 and 10 eV.

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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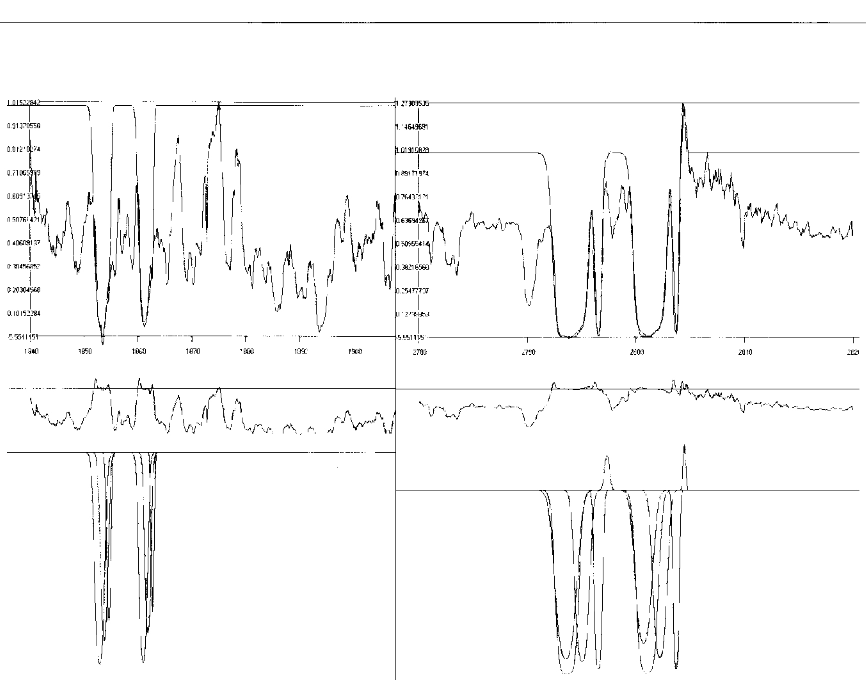

FIGURE 1. Best fit of the $\lambda\lambda$ 1854.722, 1862.782 Å Al III (left) and $\lambda\lambda$ 2795.523, 2802.698 Å absorption and emission Mg II (right) resonance spectral lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs or DACs.

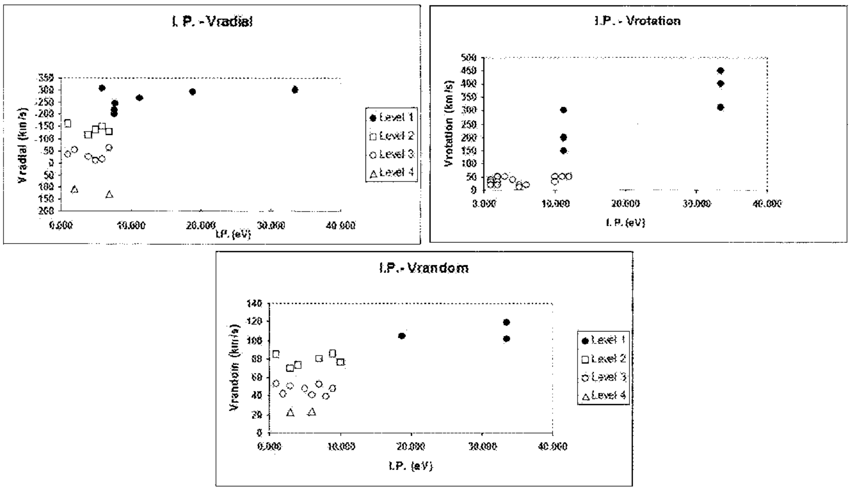

FIGURE 2. Radial (up, left), rotational (up, right) and random velocities (down) in the atmosphere of AXMon (HD 45910) spectral lines as a function of the ionization potential.

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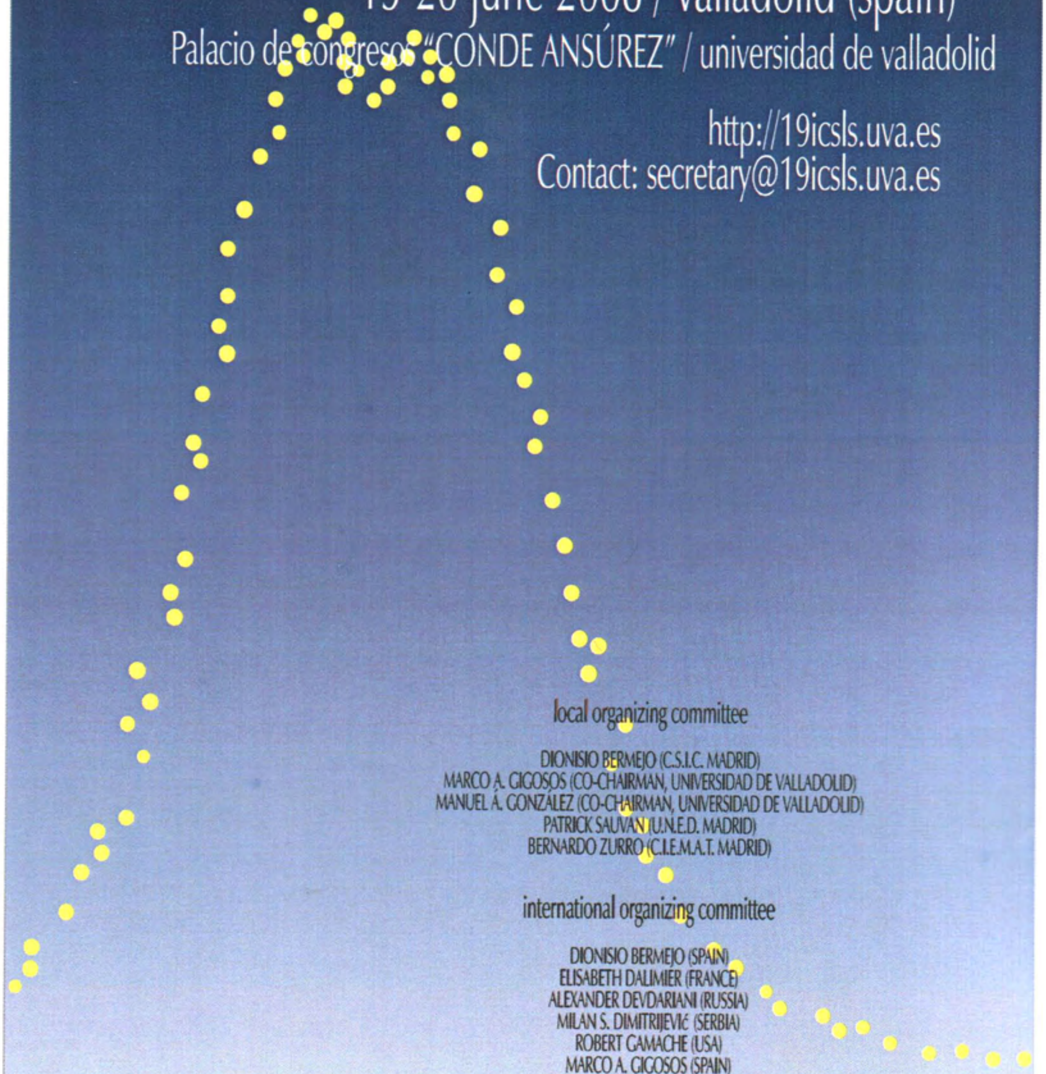

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Kinematics of Broad Absorption Line Regions of PG 1254+047

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INTRODUCTION

In a number of quasars (about 10-20%), blue-shifted, broad absorption lines (BALs) are observed in the ultraviolet spectra. These lines are formed in partially ionized outflows with velocities up to 0.1 c. The outflow is likely driven by intensive radiation of the quasar probably along the equatorial directions to the extension at least larger than the broad emission line region (BLR). Disk wind and material evaporating from the putative dust torus are two plausible scenarios for the origin of the gas. In order to understand the nature of outflow in quasars, we need to explore many properties of the outflow such as the global covering factor of BAL region, the column density and velocity fields.

Here we investigate the physical properties of Broad Absorption Line Regions (BALRs) of quasar PG 1254+047 using a model (previously developed for stellar absorption line modelling) proposed by Danezis et al. [1] (GR model). With this model one can accurately fit the observed complex profiles of both emission and absorption spectral lines. With this model we can calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM), the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines and the respective absorbed or emitted energy. We are able to explain the observed peculiar profiles of the BALs using the DACs/SACs theory, i.e. the complex profiles of the BALs are composed by a number of DACs or SACs which are created in different regions [2, 3].

In this paper we apply the GR model on the spectrum of the BALQSO PG 1254+047 (Z=1.024), taken with HST (FOS G160L,G270H), on February 17, 1993. We study the C IV $\lambda\lambda$ 1548.187, 1550.772 Å, Si IV $\lambda\lambda$ 1393.755, 1402.77 Å, N V $\lambda\lambda$ 1238.821, 1242.804 Å and Lyα λ 1215.68 Å lines.

RESULTS AND DISCUSSION

The best fit of the UV spectra with the model is shown in Figure 1. As one can see from Figure 1 there are several absorption components. In Table 1 we presented only the kinematical parameters of the absorption components, i.e. the random velocities of the studied ions as well as the rotational and radial velocities of the BALRs.

As one can see in table 1, the values of the rotational velocities are too large (from 800 km/s to 1500 km/s) indicating that the region of origin of the components is close to the massive black hole. Such large rotational and random velocities are expected near the massive black hole, in difference the large widths observed in stellar spectra (see [4, 5]).

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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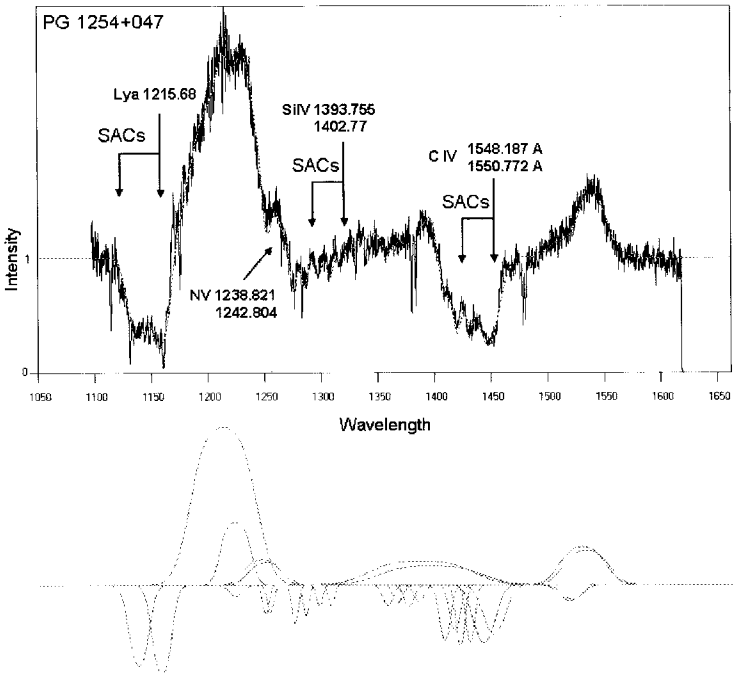

FIGURE 1. Best fit of the C IV, Si IV, N V and Lyα spectral lines. The components obtained from fit are given bottom.

TABLE 1. Random (V_{rand}), Rotational (V_{rot}) and Radial (V_{rad}) velocities (in km/s) of the studied absorption regions.

Ion	Random Velocity	Rotational Velocity	Radial Velocity
Lyα	1162	1500	1973
	1598	1500	-14303
	1598	1500	-19235
	291	800	14895
	2912	800	1726
	291	800	20098
	291	800	22688
	291	800	25154
N V	484	800	2658
Si IV	1768	1200	10442
	707	1000	5960
	581	1200	3002
	505	1000	-3645
	505	1000	-7719
C IV	1596	1000	-5804

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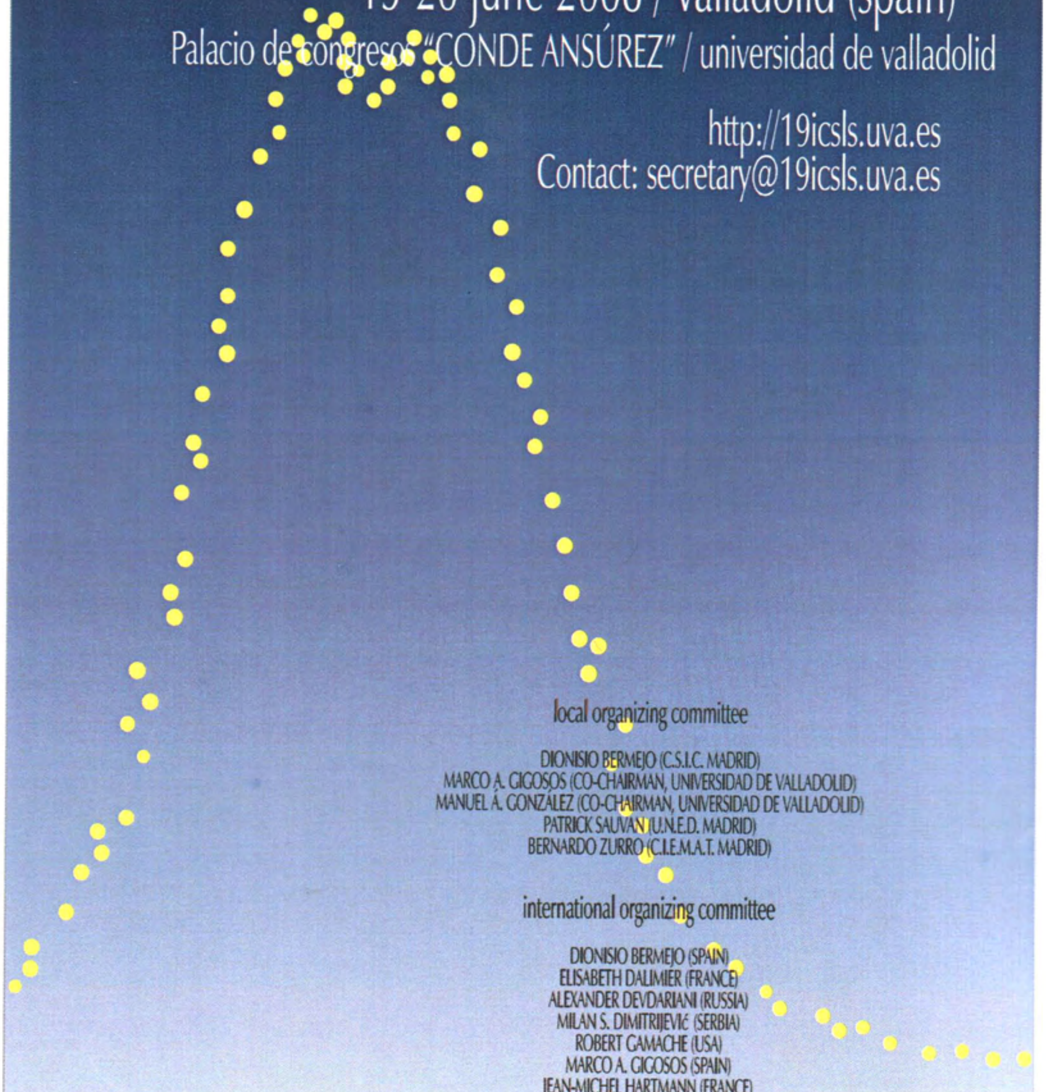

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DACs and SACs in the UV spectrum of the quasar PG 0946+301

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INTRODUCTION

In the spectra of many quasars we observe complex profiles of broad absorption lines, mainly in the case of high ionization ions (e.g. C IV, Si IV, N V). These complex profiles are composed of a number of DACs or SACs which are created in the Broad Absorption Line Regions (BALR) that result from dynamical processes such as accretion, jets, ejection of matter etc.

By applying the model proposed by Danezis et al. [1] (GR model) we can accurately fit the observed complex profiles of both emission and absorption spectral lines. With this model we can calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM), the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines and the respective absorbed or emitted energy. We are able to explain the observed peculiar profiles using the DACs/SACs theory, i.e. the complex profiles are composed by a number of DACs or SACs which are created in different regions [2, 3].

In this paper we apply the GR model on the spectrum of the BALQSO PG 0946+301 (Z=1.216), taken with HST (FOS/G400,G570), on February 16, 1992. We study the C IV $\lambda\lambda$ 1548.187, 1550.772 Å, and Si IV $\lambda\lambda$ 1393.755, 1402.77 Å lines. We point out that the C IV doublet of this BALQSO is one of the very few lines that present clearly the DACs phenomenon.

RESULTS

With GR model we were able to fit accurately the studied spectral lines (see Figure 1). Here we present only the kinematical parameters of the absorption components, i.e. the random velocities of the studied ions as well as the rotational and radial velocities of the BALRs that create the DACs or SACs of the studied lines. The calculated values are given in table 1. As one can see in table 1, some components of the C IV and Si IV resonance lines, present much larger radial velocities (large shifts). These absorption components are discrete (DACs) and appear on the left side of the main absorption features. On the other hand, the main absorption features are composed by a number of SACs (Figure 1).

TABLE 1. Random (V_{rand}), Rotational (V_{rot}) and Radial (V_{rad}) velocities (in km/s) of the studied regions

Ion	Random Velocity	Rotational Velocity	Radial Velocity
Si IV	505	400	-7611
	204	400	-9005
	204	400	-5617
	204	400	-12071
C IV	615	3000	-5998
	615	1800	-10835
	228	600	-10061
	2	700	-6385

As one can see in table 1, the values of the rotational velocities of the first two C IV components are too large. In order to explain this large broadening, we propose a new idea, based on the theory of SACs phenomenon [4, 5, 6]. The observed very large width is due to the existence of many narrow absorption lines which are created due to micro-

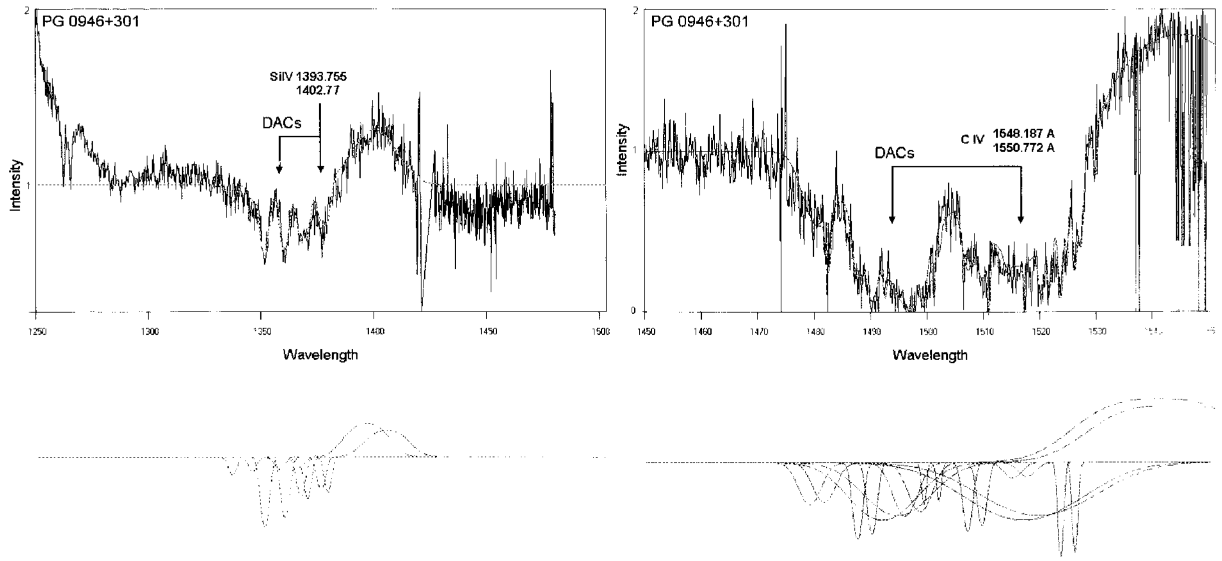

FIGURE 1. Best fit of the Si IV and C IV, resonance lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis of the observed profile to its DACs/SACs.

turbulence effects. This means that around the main density region where the main spectral line is created, there may exist some micro-turbulent movements that give rise to some narrow absorption components with different shifts, around the main spectral line. If these lines are many and have small differences in their radial velocities, they blend among themselves (SACs phenomenon) and the result may be a very broad absorption line. Thus, the very broad absorption line might result from the composition of many narrow absorption lines that are created by micro-turbulent effects.

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Similarity between DACs/SACs phenomena in hot emission stars and quasars absorption lines

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INTRODUCTION

The spectra of Hot Emission Stars and AGNs present peculiar profiles that result from dynamical processes such as accretion and/or ejection of matter from these objects. In the UV spectra of hot emission stars and AGNs the absorption lines have DACs or SACs that are shifted to the blue. In the case of hot emission stars, DACs or SACs arise from spherical density regions around the star, or from density regions far away from the star that present spherical (or apparent spherical) symmetry around their own center [1, 2, 3].

Similar phenomena can be detected in the spectra of AGNs. Wind (jets, ejection of matter etc.), BLR (Broad Line Regions) and NLR (Narrow Line Regions) are, probably, the density regions that construct these profiles of the spectral lines [3]. In order to study the observed peculiar profiles in the spectra of hot emission stars and AGNs, we use the GR model [4]. With this model we can reproduce the spectral lines complex profiles.

In this paper we indicate that DACs and SACs phenomena, can explain the spectral lines peculiarity in Hot Emission Stars and AGNs [5, 6]. We also try to connect the physical properties of absorption regions around stars and quasars.

RESULTS AND DISCUSSION

Here we applied the GR model [2, 4] in order to fit stellar and quasar absorption lines (see Figures 1-3). In both cases we can find blue-shifted components, which are indicating an outflow (wind) in both objects. Difference is in the velocities, i.e. naturally the outflow velocities in quasars are higher (∼ several 1000 km/s). But, the line profiles (as e.g. P-Cyg profile) in both objects are similar, indicating that natural phenomena are similar, but with different physical properties.

As we can see in Figure 2 (right) we can detect the DACs phenomenon in the spectra of some AGNs constructing complex profiles.

The presence of DACs phenomenon in the spectra of some AGNs lead us to search also for SACs in these spectra.

In Figure 3 (right) using the GR model we can see that the complex structure of many AGNs spectral lines can be explained with SACs phenomenon.

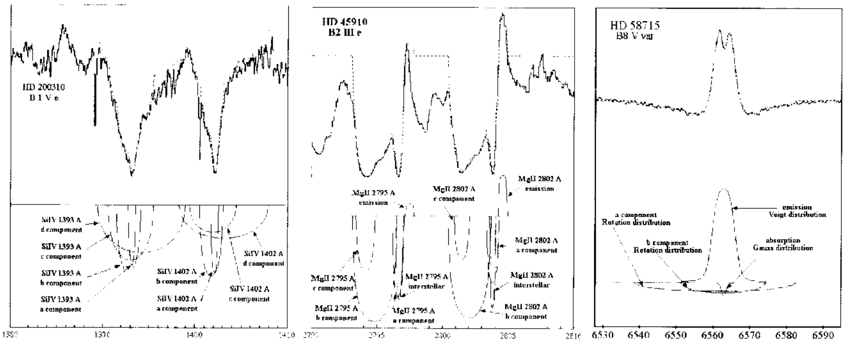

FIGURE 1. Best fit of the Si IV, Mg II and Hα spectral lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs.

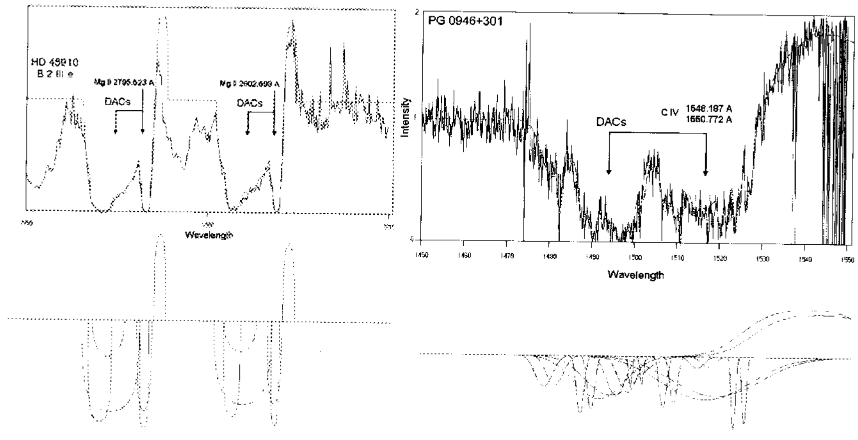

FIGURE 2. DACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the GR model fit one can see the analysis of the observed profile to its DACs or SACs.

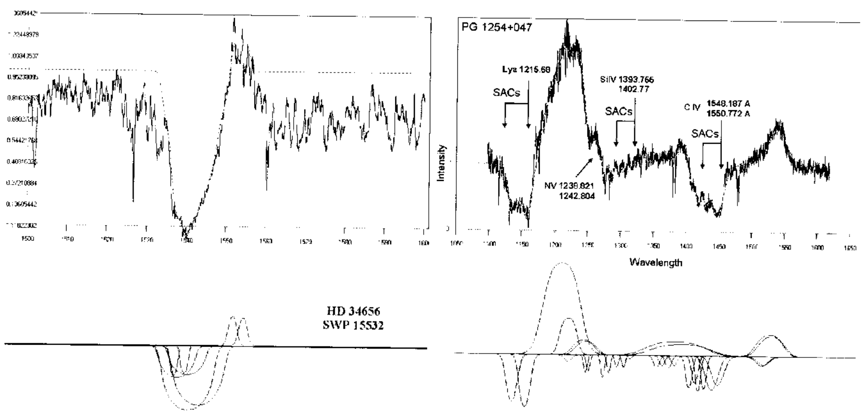

FIGURE 3. SACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the GR model fit one can see the analysis of the observed profile to its SACs.

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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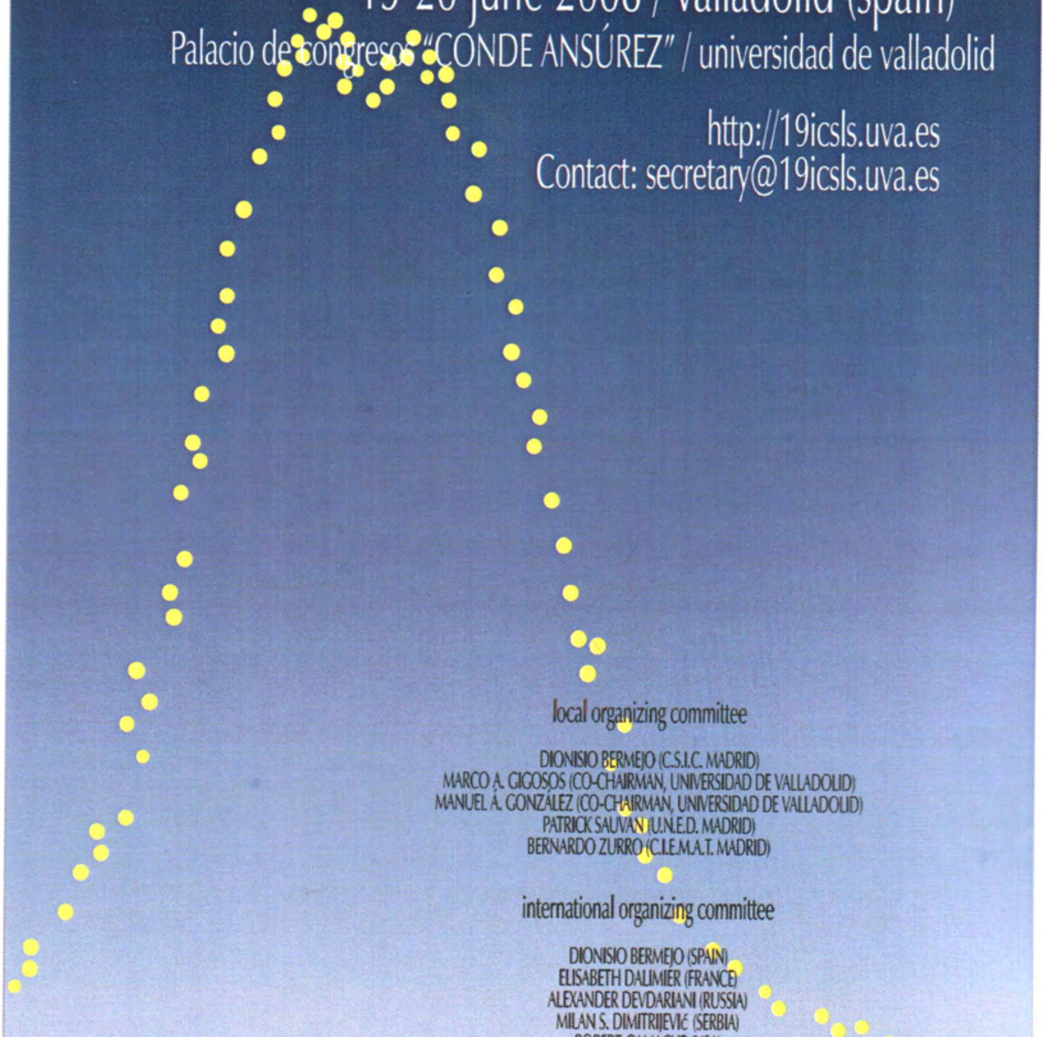

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Calculation of the shifts of argon spectral lines

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INTRODUCTION

In the previous works [1-3] the broadening of argon spectral lines emitted from surface wave plasma at atmospheric pressure have been studied. The purpose was to obtain the electron density in this type of discharge using the widths of spectral lines of the working gas, without any impurities and contaminations of the plasma.

In this work we look for the shift values of the same argon spectral lines. If their values are significant enough to be measured, it is possible to use them for plasma diagnostic too.

THEORETICAL CALCULATIONS

The theoretical calculations of the shifts of argon spectral lines have been made using semi-classical impact theory. Under atmospheric pressure the shifts of the spectral lines are due to: (i) the interactions between the emitters and the charged particles (Stark shift) and (ii) the interactions emitters - neutral atoms in a ground state.

Stark shifts

In this work, the Stark shifts have been calculated using Sahal-Bréchot theory [4, 5]. Within the semi-classical perturbation formalism, the Stark shift (d) of an isolated line originating from the transition between the initial level i and the final level f is expressed as:

$$d_{St} = n_e \int_0^{\infty} v f(v) dv \int_{\rho_3}^{\rho_d} 2\pi\rho d\rho \sin 2\phi_p \tag{1}$$

where n_e and v are the electron density and the velocity of perturbers respectively, $f(v)$ is the Maxwellian distribution of electron velocities, and ρ is the impact parameter. The phase shift ϕ_p is due to the polarization potential The cut-off parameter ρ_3, the Debye cut-off ρ_d and the symmetrization procedure are described in [4, 5].

Shift due to collisions with neutral atoms

The shift by the neutral atoms has been treated using semi-classical theory in impact approximation where the shift value d_K is given by:

$$d_K = N < \sigma'' v >= N\delta \tag{2}$$

where N is the perturber density, σ'' is the effective cross section for the impact line shift, δ is the shift coefficient, v is the relative velocity between the radiator and the perturber. Here the symbols <...> denote the thermal average over a Maxwellian distribution of the relative velocities of the interacting atoms. The interactions between the emitter and the rare-gas atoms are described using Kaulakys potential [6]. It is approximated by a superposition of polarization potentials and the Fermi pseudopotential. The polarization potentials describe the long range interactions: (i) excited electron - perturber interaction; (ii) three body interaction between the excited electron and perturber in the presence of emitter core and (iii) emitter core - perturber interaction.

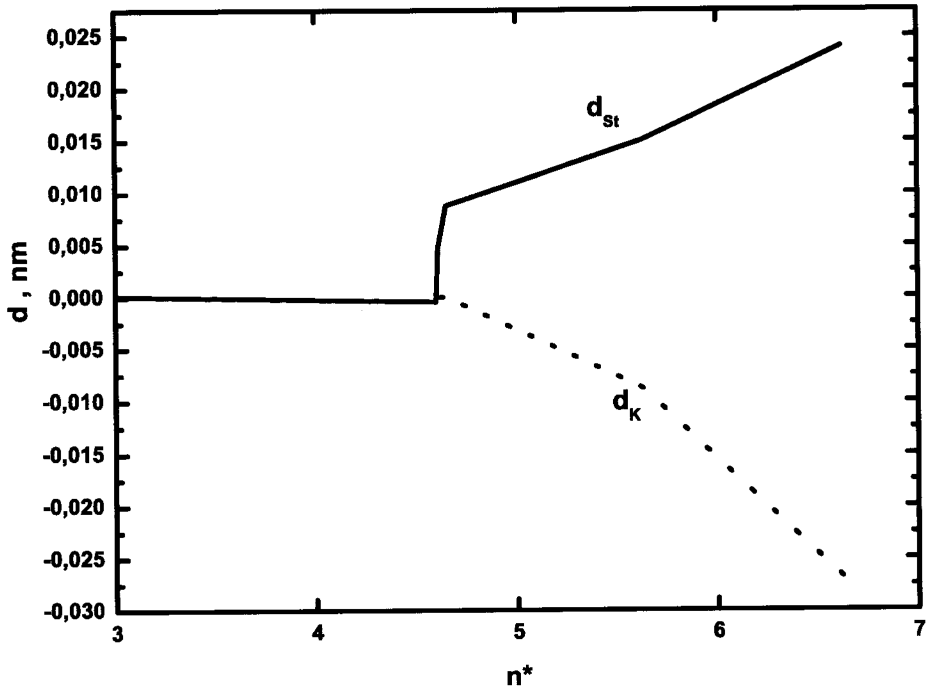

FIGURE 1. Stark shift (d_{St}) and neutral shift (d_K) of the argon spectral lines versus effective quantum number (n^*).

RESULTS

Results for the shifts of nine argon spectral lines corresponding to the transitions $3p^5nd$ - $3p^54p$ for n = 4 - 7, $3p^56s$ - $3p^54d$ and $3p^54p'$ - $3p^54s$ have been obtained. Comparison of our semi-classical Stark shift [2] and the theoretical shift caused by the neutral atom impacts, have been presented, as well as the dependence of the shift of spectral lines versus the effective quantum number.

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STARK WIDTHS IN THE Ne IV SPECTRUM

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1. INTRODUCTION

Only two experiments [1,2] deal with the Ne IV Stark FWHM (full-width at half intensity maximum, W) investigation and only three theoretical works [3-5] are devoted to the calculations of these W values. Theoretical W values (G, GM, SEM, SE) are calculated in [3] on the basis of various approximations initiated by Griem, Dimitrijević and Konjević. Thus, SE and SEM denote the results of semiempirical [6] and modified semiempirical predictions using equations (4), (5) and equations (7) - (10), respectively, from [3]. G and GM denote W values obtained on the basis of the symplified semiclassical approximation [7], with 1.4 instead of 5-(4.5/z) on the right-hand side of equation (12) in [8] for the GM values. Mentioned calculations are performed only for two Ne IV multiplets.

Stark widths of three Ne IV spectral lines (237.216 nm, 235.252 and 235.796 nm) belonging to the $3s^4P - 3p^4D^0$ transition have been calculated and measured in the linear, low pressure, pulsed neon arc plasma at 34 500 K electron temperature and at an electron density of 1.83 10^{23} m^{-3}. Our Stark FWHM values have been calculated using the semiclassical-perturbation formalism (SCPF) from [9,10], inovated and optimized several times (see e.g. [11] and references therein). Energy levels and the ionization potential of the Ne IV ions have been taken from [12]. It should be pointed out that the new value of the Ne IV ionization potential (783 890 cm^{-1}) is higher in comparison to the earlier [13] value (783 300 cm^{-1}). Our calculated Stark FWHM values are presented in the Table 2. The found new W values of the considered Ne IV lines have been compared to the existing experimental and theoretical Stark width values.

2. EXPERIMENT AND RESULTS

The modified version of the linear low pressure pulsed arc [14,15] has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm inner diameter and effective plasma length of 7.2 cm (Fig. 1 in [15]). The tube has end-on quartz windows. The working gas was neon at 130 Pa filling pressure in constant flux flowing regime. A capacitor of 14 μF was charged up to 2.5 kV. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. The line profiles were recorded using a step-by-step technique, described in our earlier publications. The spectrograph exit slit (10 μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The averaged photomultiplier signal (five shots at each position) was digitalized using an oscilloscope, interfaced to a computer.

Plasma reproducibility was monitored by the Ne II and Ne III lines radiation and, also, by the discharge current (it was found to be within 3%). Recorded line profiles can be fitted to the Voigt function as a superposition of the Gauss (instrumental and Doppler broadening) and Lorentz (Stark broadening) functions. The standard deconvolution procedure [16] was computerized using the least square algorithm. Stark widths have been obtained with ±15% accuracy at given T and N. Self-absorption can be neglected because of the small concentration of the Ne IV ions. The plasma parameters were determined using standard diagnostic methods [17] Thus, the electron temperature (T) was determined from the Boltzman-plot of 14 Ne II lines (331.98, 336.06, 337.18, 341.48, 341.69, 341.77, 350.36, 356.83, 366.41, 369.42, 429.04, 439.19, 440.93 and 441.32 nm) with a corresponding upper-level energy interval of 7.52 eV with an estimated error of ±7%, assuming the existence of LTE, according to the criterion from [7]. All necessary atomic data were taken from [18]. The electron density (N) decay was measured using well known single laser interferometry technique for the 632.8 nm He-Ne laser wavelength with an estimated error of ±7%. The electron density and temperature decay's are presented in Fig.1 (for the 2.5 kV bank energy). Our experimental W data are given in the Tab.1.

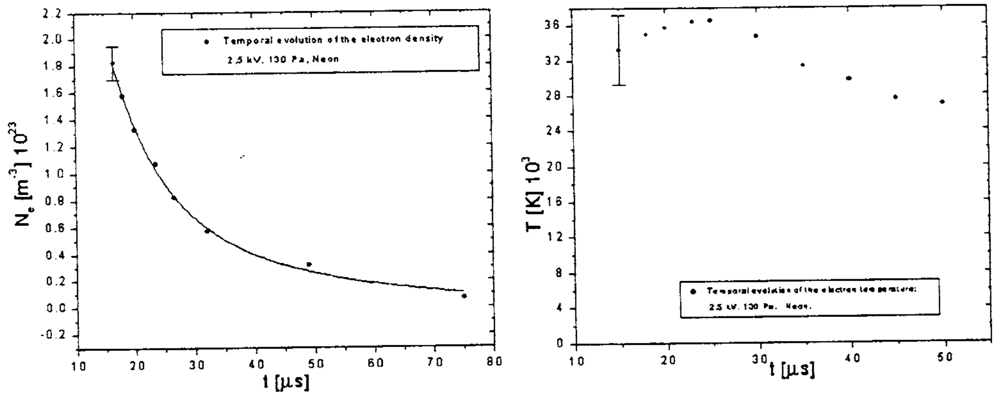

Fig.1. Electron temperature (T) and density (N) decay at 2.5 kV bank energy

Transition	λ (nm)	W (nm) 34 500 K 1.83 · 10^{23} m^{-3}
$3s^4P - 3p^4D^0$	237.216	0.0115
	235.252	0.0121
	235.796	0.0121

Table 1. Measured W values at given plasma parameters.

T (10^3)K	20	31	35	50	100	200	300	500
W(nm)	0.0078	0.0063	0.0059	0.0050	0.0037	0.0028	0.0025	0.0021

Table 2. Our calculated Stark FWHM (W) for the mean wavelength (236.1 nm) in multiplet at 1 · 10^{23} m^{-3} electron density

3. DISCUSSION AND CONCLUSION

In order to allow easy comparison among measured and calculated Stark width values, we report in Fig.2. variations of W (FWHM) with the electron temperatures for a given electron density equal to 10^{23} m^{-3}. Theoretical predictions are calculated on the basis of various approximations described above.

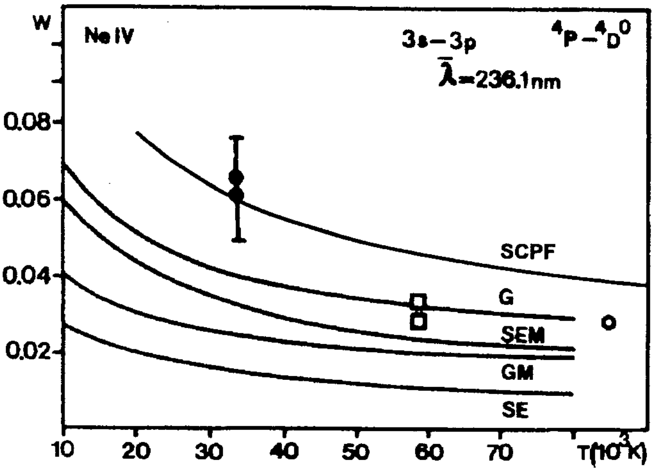

Fig.2. Stark FWHM (in 0.1 nm) values vs. electron temperature at an 10^{23} m^{-3} electron density. •, and (SCPF) this work; □, Purić et al.[1]; o, Uzelac et al. [2]. The G, GM, SEM and SE denote calculated W values taken from [3]. Error bars include uncertainty estimates in width (±15%) and electron density (±7 %) measurements. $\bar{\lambda}$ is the mean wavelength in the multiplet.

On the basis of the existing W values and our new Stark FWHM data one can conclude that our calculated values (SCPF) agree with our measured values and both lie above all other theoretical predictions (G, GM, SEM, SE) and experimental W data.

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STARK BROADENING IN ASTROPHYSICS

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The interest for Stark broadening data of good quality is additionally stimulated in last ten years by the developement of space astronomy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected.

Here is presented a review of astrophysical problems where Stark broadening data are of interest. Such problems are e.g. the research of white dwarfs and hot stars of B and A type. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level and consequently, Stark broadening contribution may become significant even in the spectrum of Sun and cooler stars

Reliable Stark broadening data are also needed for the determination of chemical abundances of elements from equivalent widths of absorption lines and for the estimation of the radiative transfer through the stellar plasmas, especially in subphotospheric layers as well as for opacity calculations. Stark broadening is of interest as well for the research of neutron stars and the investigation of radio recombination lines from molecular and ionized hydrogen clouds. Such data are of importance as well for the subphotospheric layer investigations, radiative acceleration considerations, nucleosynthesis research and other astrophysical topics.

Finaly, the results of Stark broadening study in Yugoslavia relevant to astrophysical problems have been reviewed.

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THE ELECTRON-IMPACT EFFECT IN HOT STELLAR ATMOSPHERES: Nd II LINES

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Abstract. The Stark widths for four Nd II lines have been calculated using the simplified modified semiemprical approach (MSE). Using the SYNTH program for spectra synthesis we discuss the influence of the electron-impact broadening effect on Nd II spectral line shapes from hot stellar atmospheres.

1. INTRODUCTION

The spectral lines of rare-earth elements are present in hot star spectra, especially in spectra of CP stars. The electron-impact broadening is the main broadening mechanism in A and B type star atmospheres (see e.g. [1]). The electron-impact broadening data are needed for various problems in astrophysics and physics, as e.g. for diagnostic and modeling of laboratory and stellar plasma, investigation of its physical properties and for abundance determination. These investigations provide us with useful information for modeling of stellar evolution. As an example, the abundances study in stellar atmospheres provides evidences for the chemical composition of the stellar primordial cloud, processes occurring within the stellar interior, and the dynamical processes in stellar atmosphere. Here we present Stark widths for four Nd II lines and discuss the electron-impact mechanism in stellar atmospheres.

2. NEODYMIUM LINES IN SPECTRA OF STELLAR ATMOSPHERES

The Nd II lines are present in stellar atmospheres (see e.g. [2-4]). Here we have considered the four lines of Nd II (4012.25Å, 4061.09Å, 4156.08Å, 4303.58Å) which are observed in stellar spectra. Also, these lines are present in the spectrum of HR 7775 (T_{eff} = 10650 K, log g = 4.05), and it is interesting that from these lines different values of Neodymium abundance have been obtained [2, 3]. In Table 1. transitions, oscillator strengths, and abundances obtained from considered lines are given.

Table 1. The atomic data and equivalent widths for considered four lines of Nd II, observed in the spectrum of HR 7775 [2, 3]. In the columns are presented transitions, wavelengths, oscillator strengths taken from Ref. [5], equivalent widths and abundances calculated for every line by using W_λ from[3].

transition	λ(Å)	log *gf*	Adelman	Guthrie	log (N_{Nd}/N_H)
			W_λ(mÅ)	W_λ(mÅ)	
6s $^6I_{17/2} \rightarrow$ 6p $^6K^o_{19/2}$	4012.25	+0.58	17	20	-7.46
6s $^6I_{15/2} \rightarrow$ 6p $^6K^o_{17/2}$	4061.09	+0.57	11	12	-8.01
6s $^6I_{11/2} \rightarrow$ 6p $^6K^o_{13/2}$	4156.08	+0.13	11	12	-7.74
6s $^6I_{7/2} \rightarrow$ 6p $^6K^o_{9/2}$	4303.58	+0.26	15	15	-7.78

2. RESULTS AND DISCUSSION

Concerning the very complex and incomplete spectrum of Nd II the simplified modified semi-empirical approach [6] has been used for calculation of Nd II lines. The results of our calculation are presented in Table 2.

Table 2. Results of calculation by using simplified MSE [6], for four transitions of (6s $^6I \rightarrow$ 6p ^6K) multiplet. Limiting temperatures ($3kT/2m\Delta E_{if} \leq 2$) from the application of the simplified MSE are in last row for every element. The electron density is 10^{23} cm^{-3}.

Transition / λ(Å)	T_{eff} (K)	*W*(Å) Stark width
6s $^6I_{17/2}$ - 6p $^6K^o_{19/2}$ λ = 4012.25 Å	5000	0.602
	10000	0.426
	15000	0.347
	20000	0.301
	25000	0.269
	33800	0.231
6s $^6I_{15/2}$ – 6p $^6K^o_{17/2}$ λ = 4061.09 Å	5000	0.582
	10000	0.411
	15000	0.336
	20000	0.291
	25000	0.260
	30800	0.234
6s $^6I_{11/2}$ – 6p $^6K^o_{13/2}$ λ = 4156.08 Å	5000	0.550
	10000	0.389
	15000	0.317
	20000	0.275
	25000	0.246
	27300	0.235
6s $^6I_{7/2}$ – 6p $^6K^o_{9/2}$ λ = 4303.58 Å	5000	0.547
	10000	0.387
	15000	0.316
	20000	0.273
	25000	0.245
	26800	0.236

We have analyzed also the influence of electron-impact broadening mechanism on equivalent width and consequently on determination of Neodymium abundance in HR 7775 star atmosphere. In order to test the importance of the electron-impact broadening effect in determination of Neodymium abundance, we have synthesized the line profiles of 6s $^6I_{17/2}$ → 6p $^6K^o_{19/2}$ (4012Å), 6s $^6I_{15/2}$ → 6p $^6K^o_{17/2}$ (4061Å), 6s $^6I_{11/2}$ → 6p $^6K^o_{13/2}$ (4156Å), 6s $^6I_{7/2}$ → 6p $^6K^o_{9/2}$ (4303Å), using SYNTH code e.g. [7] and the Kurucz's ATLAS 9 code e.g. [8] for stellar atmosphere model T_{eff} = 10000 K and log g = 4.0, with similar characteristics as in the case of HR 7775 [3]. We have modified the SYNTH code, which uses log W(rad/s) per electron for T_{eff} = 10000 K as an input parameter replacing them by two input parameters: A_0 and A_1 (Eq. (2) in Ref. [1]).

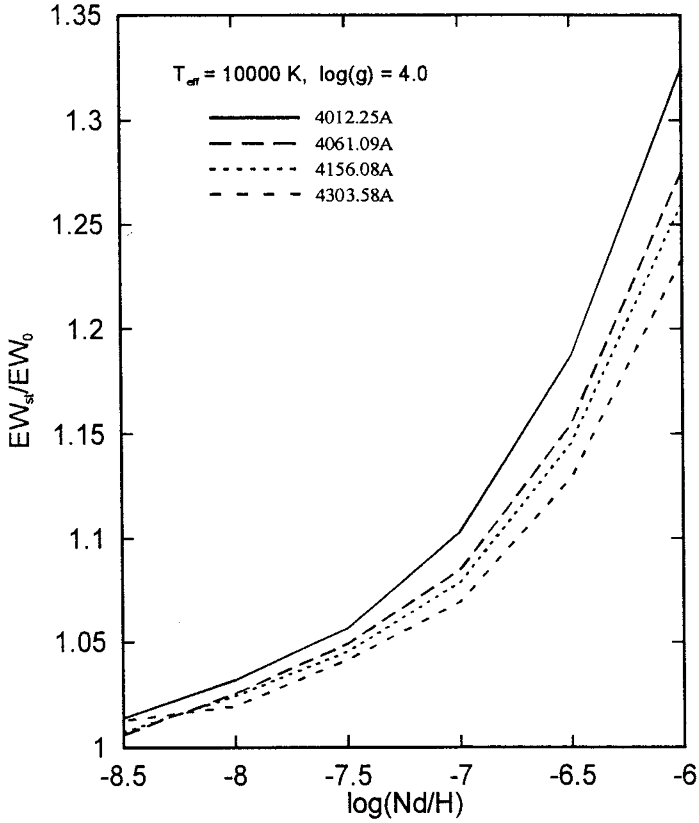

Figure 1. The ratio of EW_{St}/EW_0 for all four considered lines as a function of Nd abundance.

We have calculated the equivalent widths with the electron-impact broadening effect (EW_{st}) and without it (EW_0) for different abundances of Neodymium. The ratio of equivalent widths for NdII[4012Å], NdII[4061Å], NdII[4156Å] and NdII[4303Å] lines calculated with the electron-impact broadening effect and without it is presented in Fig. 1. As one can see from Fig. 1. the electron-broadening effect is more important in the case of higher abundance of Neodymium. The equivalent width increases with abundance for all considered lines. If one ignores this effect, in the case of considered lines, the obtained Neodymium abundance may be 30% higher. Consequently, the Stark broadening effect should be taken into account in the process of Neodymium abundance determination.

These calculated data, together with other Stark broadening parameters for various elements, will be included in Belgrade Astronomical Database (BELDATA) on Internet address `http://www.aob.bg.ac.yu`

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Electron-Impact Broadening of C II Spectral Lines

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Using semiclassical perturbation approach in the impact approximation, we have obtained Stark broadening parameters for 148 CII multiplets. Energy levels and oscillator strengths are taken from the TOPbase database. Results are obtained as a function of temperature, for a perturber densities of 10^{14}, 10^{17} and 10^{18} cm^{-3}. In addition to electron-impact full half widths and shifts, Stark broadening parameters due to singly ionized carbon-impacts have been calculated, in order to provide Stark broadening data for the important charged perturbers in the atmospheres of carbon white dwarfs. Obtained results have been compared to the existing experimental data. Also, the influence of the choice of oscillator strengths on the result of calculations was investigated on the case of the 3s-np and 3d-nf spectral series. The complete results will be published in Ref [1] and here only illustrative examples will be shown.

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The Quasi-molecular Absorption Bands In UV Region Caused By The Non- symmetric Ion –atom Radiative Processes In The Solar Photosphere

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The aim of this research is to show that the radiative processes in strongly non- symmetric ion-atom collisions significantly influence on the opacity of the solar photosphere in UV region. Within this work only the $He+H^+$ and $H+A^+$ ion-atom systems, where A is the atom of one of the metal (Mg, Si and Al), are taken in to account. It is caused by the fact that the needed characteristics of the corresponding molecular ions, i.e. molecular potential curves and dipole matrix elements, have been determined by now. Here the non-symmetric radiative processes are considered under the conditions characterizing the non-LTE standard model of the solar atmosphere [1], which gives the possibility to performed all needed calculations and determined the corresponding spectral absorption coefficients. It is shown that the examined processes generate rather wide quasi-molecular absorption bands in the UV and VUV regions, whose intensity is comparable and sometimes even larger than the intensity of known one's caused by the $H+H^+$ radiative collision processes [2], which are included now in the solar atmosphere models [3]. Consequently, the presented results suggest that the non-symmetric ion-atom absorption processes have to be also included in standard models of the solar atmosphere.

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES AND PROGRESS REPORTS

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ON THE STARK BROADENING OF THE 537.8 nm AND 441.6 nm Cd II LINES

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1. INTRODUCTION

Data on Stark broadening parameters are not only of interest for example for plasma diagnostic, opacity calculations or the investigation/modeling of a particular line or emitter spectrum [1] but as well for different examinations of regularities and systematic trends for e.g. homologous atoms [2] or in general [3]. Moreover, we do not know a priori the chemical composition of a star and with the development of space born techniques, the astrophysical importance of up to now often astrophysically meaningless lines increases.

Stark broadening parameters of ionized cadmium spectral lines have been examined several times experimentally [4-7] and theoretically [8] within the modified semi-empirical approach [9,10]. They have been also estimated using the regularities and systematic trends [11].

In this work, the full semi-classical perturbation approach [12,13] will be applied and a jointly laser physical application of the results; namely the role of Stark broadening on the mode properties of hollow cathode lasers will be discussed.

2. STARK BROADENING PARAMETERS CALCULATION

The semi-classical perturbation method has been discussed in detail in Refs. 12 and 13 and a brief summary of the method and all inovations are given in Ref. 14. Energy levels for Cd II lines have been taken from Ref. 15. Oscillator strengths have been calculated by using the method of Bates and Damgaard [16,17]. For higher levels, the method described in Ref. 18 has been used.

Our semi-classical results for Stark full width at half maximum (FWHM) are shown in Table 1 for a perturber density $N_e = 1.0 \times 10^{14}$ cm^{-3} (of interest for laser research) and electron temperatures T_e = 1 000 – 50 000 *K*.

can rise up to the cathode voltage which is commonly several hundred V. For laser excitation the high energy tail is of importance, but concerning Stark broadening the low electron energy part is important: In a He-Zn laser discharge - which is very similar to the He-Cd one - it was found that in the middle of the cathode *the electron density amounts to* $N_e = 5.10^{13} - 10^{14} cm^{-3}$, *about two order of magnitude larger, than that in the positive column of a glow discharge* [29]. Different model calculations and measurements are available [30,31]. Especially for the He–Cd gas mixture in a transversal hollow cathode discharge tube with 20 - 25 mbar filling pressure, at ~100mA cm^{-2} current density and at ~300 V cathode voltage, E_e ~ 0.2 eV and N_e ~ 10^{14} cm^{-3} can be assumed as a good estimation.

3.2. Stark broadening of the Cd II lines

Results are summarized in Tables 2 and 3.

Table 2. Broadening data for the Cd II 537.8 nm line in a hollow cathode (HC) He-Cd discharge

Natural line-width		93 MHz	Calculated from measured level lifetime data
Pressure broadening constant		12 MHz/mbar	Measured at low current density (~10mA/cm^2) [32]
Homogeneous (pressure + natural) line-width at 23 mbar		370 MHz	
Doppler (inhomogeneous) line-width		~1300 MHz	Estimated value based on experimental data at low current density
Ratio of homogeneous and inhomogeneous line-widths		0.28	Without taking into account Stark broadening
Typical HC laser discharge plasma parameters (at ~100 mA/cm^2 current density)	Electron density	~10^{14}cm^{-3}	Estimated values from measurements[29] and model calculations[30,31]
	Electron temperature	~2300 K	
Stark width at laser conditions		290 MHz	Extrapolated value based on previous calculations [8]
Homogeneous (pressure + natural + Stark) line-width at 23 mbar		660 MHz	
Ratio of homogeneous and inhomogeneous line-widths		~ 0.50	Including Stark broadening

4. Discussion

Due to the complexity of the problem there isn't any exact limit for turning a laser to single mode operation. It was found, however, that a value of ~0.4 for the ratio of the homogeneous line width to the inhomogenious one is enough. For the *green* HC He-Cd II laser the pressure broadened natural line-width is only about 28% of the Doppler one, and therefore this ratio is

Table 1. Electron-impact broadening full half-widths (FWHM) and shifts for the Cd II 4415.6 Å ($5s^2\,^2D_{5/2}$ - $5p\,^2P_{3/2}$) spectral line at a perturber density of 1.0×10^{14} cm^{-3} and temperatures from 1000 K up to 50 000 K.

T_e (K)	WIDTH (Å) (FWHM)	SHIFT (Å)
1 000	0.978×10^{-3}	0.862×10^{-4}
2 000	0.566×10^{-3}	0.702×10^{-4}
5 000	0.336×10^{-3}	0.598×10^{-4}
10 000	0.244×10^{-3}	0.466×10^{-4}
20 000	1.776×10^{-3}	0.346×10^{-4}
50 000	1.200×10^{-3}	0.240×10^{-4}

3. STARK BROADENING IN HOLLOW CATHODE LASER DISCHARGES

Ionic lines can be effectively excited in a hollow cathode (HC) discharge due to the presence of high energy electrons. It has been used for laser purposes first in 1970 for the excitation of the He-Cd II laser, where strong oscillation was observed at red, green and blue Cd II transitions [19]. Since then a lot of metal vapor and noble gas HC laser transitions were found [20,21].

An interesting feature of the HC lasers is that they oscillate usually in a single axial mode without any optical selection [22]. This property has been attributed to the large homogeneous line-width due to the relatively large filling pressures. The effect of the gas pressure on the laser mode structure has been proved for several HC systems [23,24]. Recent studies have shown, however, that - at the green He-Cd II laser - pressure broadening is not large enough to explain single mode operation [7].The aim of this work was to show that at the green HC He-Cd II laser the Stark broadening has also to be taken into account in explaining single mode operation. It is shown too, that -in contrary - the multi-mode operation of the blue He-Cd II laser can be attributed to the small natural, pressure and Stark broadening.

3.1. The HC laser discharge

For laser purposes the discharge inside the cathode is used for the excitation. Different HC geometries are applied; most frequently "longitudinal" or "transversal" systems[25]. The typical pressure in the tube is 10-25 mbar. In a HC discharge the electron energy distribution function has generally a nearly Maxwellian low energy part with a high energy tail [26,27,28]. The mean energy of the low energy part amounts to $E_e = 0.1 - 1$ eV, while the high energy tail too small to explain the observed single mode operation. But if we take into account the Stark broadening, this results in a homogeneous line-width of *~660 MHz* which is ~ *50%* of the Doppler width; i. e. this ratio is already large enough to result in single mode operation.

Table 3. Broadening data for the Cd II 441.6 nm line in a hollow cathode (HC) He-Cd discharge

Natural line-width		47 MHz	Calculated from measured level lifetime data
Pressure broadening constant		6.5 MHz/mbar	From measurement [32]
Homogeneous (pressure + natural) line-width at 23 mbar		200 MHz	
Doppler (inhomogeneous) line width (for Cd mono isotope)		~1600 MHz	Estimated value based on experimental data at low current density
Ratio of homogeneous and inhomogeneous line-widths		0.13	Without taking into account Stark broadening
Typical HC laser discharge plasma parameters (at ~100 mA/cm^2 current density)	Electron density	~10^{14}cm^{-3}	Estimated values from measurements[29] and model calculations[30,31]
	Electron temperature	~2300 K	
Stark width at laser conditions		83 MHz	From this work
Homogeneous (pressure + natural + Stark) line-width at 23 mbar		283 MHz	
Ratio of homogeneous and inhomogeneous line-widths		~0.18	Including Stark broadening

At the *blue* HC He-Cd II laser the situation differs from that of the green one. Even if we take into account Stark broadening, the homogeneous line-width amounts only 18 % of the inhomogeneous (Doppler) one. Therefore this laser operates always in multi-mode.

As a conclusion it can be stated, that Stark broadening in HC laser discharges can give a significant contribution to the homogeneous line-width, but its actual role depends on the properties of the atomic or ionic levels involved.

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ON THE STARK BROADENING OF Be III SPECTRAL LINES

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1. INTRODUCTION

For laboratory plasma diagnostics as well as for different astrophysical problems like numerical modeling of stellar plasma, abundance determinations, opacity calculations, data on Stark broadening parameters of Be III spectral lines may be of interest. Such data are as well of interest for examinations of regularities and systematic trends [1,2].

Stark broadening parameters of 12 Be III spectral lines have been obtained [3] within the semiclassical perturbation approach [4-6]. However, the recently published analysis of the spectrum and term system of Be III [7], enables the calculation of Stark broadening parameters for 52 additional multiplets, with the standard accuracy. The aim of this work is to determine this additional parameters in order to extend the set of available Stark broadening data which we organize now in the database BELDATA.

2. STARK BROADENING PARAMETERS CALCULATION

The semi-classical perturbation method [4,5] has been discussed together with all innovations e.g. in Ref. [6]. Energy levels for Be III lines have been taken from new analysis of this spectrum and the corresponding term systemes given in Ref. [7]. Oscillator strengths have been calculated by using the method of Bates and Damgaard [8,9]. For higher levels, the method described in Ref. 10 has been used.

As an example of the obtained results, Stark full widths at half maximum (FWHM) and shifts for Be III ($1s^2\ {}^1S$ - $3p\ {}^1P$) and Be III ($1s^2\ {}^1S$ - $5p\ {}^1P$) multiplets are shown in Tables 1 and 2 respectively, for a perturber density of $N_e = 1.0 \times 10^{17}$ cm^{-3} and electron temperatures T_e = 10 000 – 300 000 *K*.

Table 1. Electron-impact broadening full half-widths (FWHM) and shifts for the Be III ($1s^2\ ^1S$ - $3p\ ^1P$) multiplet at a perturber density of 1.0 x 10^{17} cm^{-3} and temperatures from 10 000 K up to 300 000 K.

T_e (K)	WIDTH (Å) (FWHM)	SHIFT (Å)
10 000	0.332 E-3	-0.288 E-4
20 000	0.254 E-3	-0.212 E-4
50 000	0.184 E-3	-0.201 E-4
100 000	0.147 E-3	-0.177 E-4
200 000	0.130 E-3	-0.155 E-4
300 000	0.106 E-3	-0.123 E-4

Table 2. Electron-impact broadening full half-widths (FWHM) and shifts for the Be III ($1s^2\ ^1S$ - $5p\ ^1P$) multiplet at a perturber density of 1.0 x 10^{17} cm^{-3} and temperatures from 10000 K up to 300 000 K.

T_e (K)	WIDTH (Å) (FWHM)	SHIFT (Å)
10 000	0.237 E-2	-0.335 E-3
20 000	0.199 E-2	-0.316 E-3
50 000	0.160 E-2	-0.269 E-3
100 000	0.135 E-2	-0.224 E-3
200 000	0.121 E-2	-0.192 E-3
300 000	0.986 E-3	-0.142 E-3

Since Be III spectral lines are of interest for laboratory as well as for astrophysical plasma research and modeling, we hope that the obtained additional Stark broadening data will be of interest.

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STARK WIDTHS IN THE Si III SPECTRUM

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1. INTRODUCTION

Silicon ions are the most present emitters or absorbers in a many kinds of the cosmic leight sources. As impurities they are present also in a many high current laboratory plasma sources.The knowledge of the doubly ionized silicon (Si III) spectral lines Stark parameters is necessary in various astrophysical calculations.As an example, the silicon ionisation balance can be considered as a useful tool for temperature diagnostic in the B-stars.Thus, in the work[1] spectral lines of Si II, Si III and Si IV emitted by non LTE plasma have been used for temperature determination in B-stars. A number of work is devoted to the experimental and theoretical investigations of the Si III spectral lines Stark FWHM (full-width at half intensity maximum, W) [2].However, for the $3d-4p, 4d-5f$ and $4f-5g$ transitions in the Si III spectrum no theoretical W values exists.

The aim of this work is to present the first calculated W values in mentioned transitions. Besides, we have calculated W values ,also, for the lines belonging to the $4p-4d$, $4s-4p$ and $4p-5s$ transitions on the basis of the semiclassical perturbation (SCPF) formalism The calculated W values have been compared to our and other experimental Stark FWHM values.

2. METHOD OF CALCULATION

The semiclassical perturbation formalism, as well as the corresponding computer code [3,4], have been updated and optimized several times [4-8]. The calculation procedure with the discussion of updatings and validity criteria, has been briefly reviewed in [3,4], so that here we give only the final results of the calculations. Atomic energy levels have been taken from [9]. One should mention that in the Si III spectrum many of the known terms are affected by configuration interactions and some needed here are not experimentally determined. Consequently the obtained theoretical results might be with larger error than usual for the semiclassical perturbation method (±30%).Our calculated W values are presented in Table 1.

3. EXPERIMENT

Our experimental set-up system, the used line profiles recording technique and plasma diagnostic procedure have been described in our earlier works [10,11].

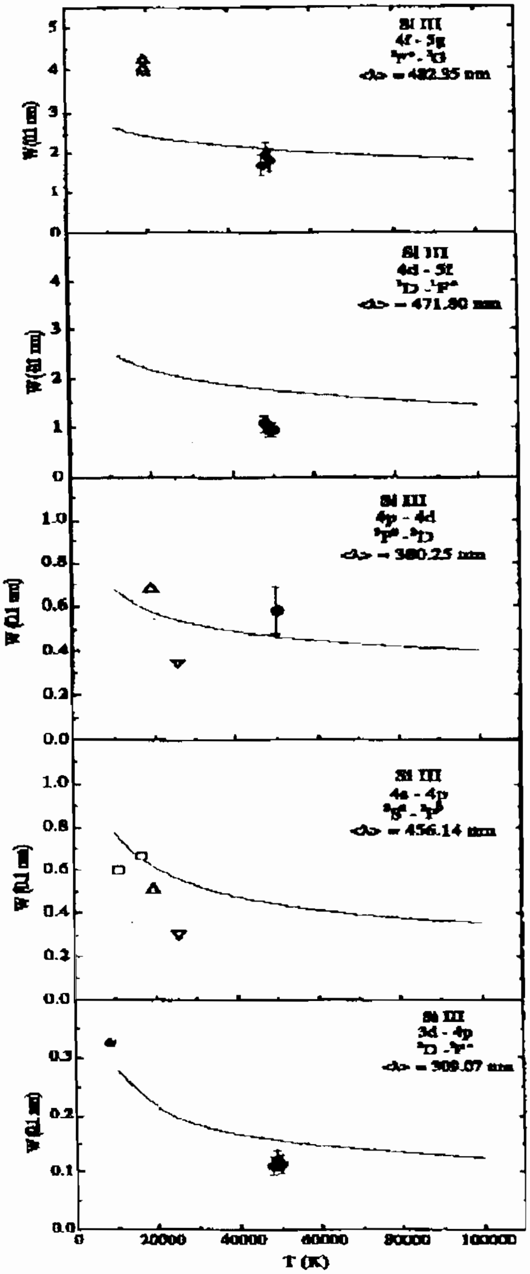

Fig. 1. Stark FWHM (in 0.1 nm) vs. electron temperature at 10^{23} m^{-3} electron density. , our calculated (SCPF) and •, experimental values. △, González et al.[14]; ▽, Platiša et [13] and □, Purić et al [12].

4. RESULTS

Our calculated W values are presented in Table 1.

	TRANSITIONS AND MEAN WAVELENGTHS (in nm)					
T	3d-4p 309.07	4p-4d 380.25	4s-4p 456.14	4p-5s 323.88	4d-5f 471.80	4f-5g 482.35
1	27.9	67.8	77.5	60.0	254	273
2	20.8	54.9	57.0	46.5	211	239
5	15.0	45.2	41.6	38.3	170	204
10	12.5	40.2	35.2	34.6	145	182
15	11.4	37.7	32.4	32.4	132	170
30	10.0	33.7	28.6	29.0	113	153

Tab.1. Electron Stark FWHM (in pm) for various transitions in the Si III spectrum at given electron temperatures (T in 10^4 K) and at 10^{23} m^{-3} electron density calculated by the use of the SCPF approaches.

Stark FWHM dependence on the electron temperatures are presented in Figure 1.

On the basis of the Fig.1 one can conclude existing of the tolerable agreement between our calculated and experimental W values within the accuracy of the experiments and uncertainties of the theory. Similar behavior show results from [12] and [14] except the $4f-5g$ transition. Results from [13] lie below our SCPF values.

Acknowledgment. This work is a part of the projects "Determination of the atomic parameters on the basis of the spectral line profiles" and "Influence of collision processes on astrophysical plasma lineshapes" supported by the Ministry of Science, Technologies and Development of the Republic of Serbia. S.Djeniže is grateful to the Foundation "Arany János Közalapitvány" Budapest, Hungary.

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STARK BROADENING PARAMETERS OF THE 763.51 nm Ar I SPECTRAL LINE

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1. INTRODUCTION

Characteristics of the Stark broadened 763.51 nm Ar I spectral line profile have been measured at electron densities between 6.7×10^{22} and 7.1×10^{22} m^{-3} and electron temperatures between 15 000 and 19 200 K in a plasmas created in three various discharge conditions using a low pressure pulsed arc as an optically thin and reproductive plasma source operated in the argon-helium and argon-hydrogen gas mixtures. On the basis of the observed asymmetry of the line profile we have obtained their ion broadening parameters (A) caused by the influence of the ion microfield and also the influence of the ion dynamic effect (D) to the line shape. Our A and D parameters represent the first data obtained experimentally by the use of the line profile deconvolution procedure. The total Stark width (W_t) is also obtained with previously separated electron (W_e) and ion (W_i) components.

Although the significant number (6) of the experiments [1-6] dedicated to the 763.510 nm Ar I spectral line width measurement exists only one work [6] deals with their theoretical calculation. In this paper the total Stark FWHM (full-width at half intensity maximum, W_t) data obtained as a sum of the electron (W_e) and ion (W_i) contribution on the basis of the semiclassical perturbation formalism (SCPF) have been presented (Ref. [6] and references therein).

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc [7-11] has been used as a plasma source. The working gas were argon-helium (72% Ar + 28% He) and argon-hydrogen (97% Ar + 3% H_2) mixtures. The used tube geometry and corresponding discharge conditions are presented in [13].

Spectroscopic observation of spectral lines was made end-on along the axis of the discharge tube.

The line profiles were recorded by a step-by-step technique using a photomultiplier (EMI 9789 QB and EMI 9659B) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in the first order) system. The instrumental FWHM of 8 pm was obtained by using narrow spectral lines emitted by the hollow cathode discharge. The spectrograph exit slit (10 μm) with the calibrated photomultipliers was micrometrically traversed along the spectral plane in small wavelength steps (7.3 pm). The averaged photomultiplier signal (five shots in each position) was digitized using an oscilloscope, interfaced to a computer.

Plasma reproducibility was monitored by the Ar I (763.510 nm, 772.376 nm, 706.722 nm and 738.398 nm) lines radiation and, also, by the discharge current using the Rogowski coil signal (it was found to be within ±5%). Plasma parameters are determined using well known diagnostic methods described in [12].

3. DECONVOLUTION PROCEDURE

The used deconvolution procedure in its details is described in [12] and [13]. It includes a new advanced numerical procedure for deconvolution of theoretical asymmetric convolution integral of a Gaussian and a plasma broadened spectral line profile $j_{A,R}(\lambda)$ for spectral lines. This method gives complete information on the plasma parameters from a single recorded spectral line. The method determines all broadening (W_t, W_e, W_i, A, D) and plasma parameters (N, T) self-consistently and directly from the shape of spectral line without any assumptions or prior knowledge. All one needs to know is the instrumental width of the spectrometer. The measured profiles were convoluted due to the convolutions of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadenings [14]. Van der Waals and resonance broadenings [14] were estimated to be smaller by more than an order of magnitude in comparison to Stark, Doppler and instrumental broadenings. The deconvolution procedure was computed using the least Chi-square function [12, 13].

4. RESULTS AND DISCUSSION

Line broadening parameters ($W_t^{exp}, W_e^{exp}, W_i^{exp}, A^{exp}$ and D^{exp}) and plasma parameters (N^c and T^c) obtained by our deconvolution procedure of the recorded line profiles together with the measured N_{exp} (in 10^{22} m^{-3}) and T_{exp} (in 10^3 K) values are presented in Table 1. W_t values of other authors are also given together with the theoretical (DSD) predictions [6] of the W_e^{DSD}. The W_t, W_e and W_i values are given in pm. A and D values are dimensionless.

Table 1. Line broadening parameters: W_t^{exp}, W_e^{exp}, W_i^{exp}, W_e^{DSD} and W_i^{DSD} values are given in pm. A^{exp} and D^{exp}) values are dimensionless. Plasma parameters N^c and N_{exp} are in 10^{22} m^{-3} and T^c and T_{exp} are in 10^3 K. W_t values of other authors are also given together with the theoretical (DSD) predictions [6] of the W_e^{DSD}.

N_{exp}	N^c	T_{exp}	T^c	W_t^{exp}	W_e^{exp}	W_i^{exp}	A^{exp}	D^{exp}	Ref.	W_e^{DSD}	W_i^{DSD}	W_t^{exp}/W_t^{DSD}
6.7	6.5	15.6	15.5	69	65	4	0.057	2.663	Tw	55	20	0.92
7.0	6.8	16.0	16.0	73	68	5	0.058	3.274	Tw	57	21	0.94
7.1	7.5	16.2	16.6	74	69	5	0.058	3.255	Tw	58	21	0.94
1.0		10.0		3.7			0.044		[1]			
5.0		11.5		50					[2]			
14.5		13.8		146					[3]			
2.0		10.0		40					[4]			
0.4		11.1		3.8					[5]			
3.8		13.0		28					[6]			

It turns out that our W_e^{exp} are the first separated experimental electron Stark width data obtained using line deconvolution procedure. They are in good agreement (within ±16%) with W_e^{DSD} [6] values. We have found contribution of the ion influence to the line broadening due to the quasistatic ion and ion dynamic effects. Besides, we have also found that in the ion contribution the ion dynamic effect play an important role. This effect multiply the quasistatic ion influence about 3 times at our plasma parameters and composition. Our W_i^{exp} values agree well (within 8%) with W_i^{DSD} values. Taking into account the $N^{1/4}$ normalization factor [14] the A value from [1] normalized to our electron density is 0.072. This is about 24% over our A^{exp} value making the agrement between them tolerable. Our W_t^{exp} values well agree with those from Ref. [3]. It should be pointed out that N and T values obtained experimentally (N_{exp} and T_{exp}) and also on the basis of the line deconvolution procedure (N^c and T^c) show excellent mutual agreement (within 3%) providing confirmation of the validity of the used deconvolution procedure.

Acknowledgements This work is a part of the projects "Determination of the atomic parameters on the basis of the spectral line profiles" and "Influence of collision processes on astrophysical plasma lineshapes" supported by the Ministry of Science, Technologies and Development of the Republic of Serbia. S. Djeniže is grateful to the Foundation "Arany János Közalapitvány" Budapest,

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APPLICATIONS OF THE MODIFIED SEMIEMPIRICAL METHOD FOR STELLAR PLASMA INVESTIGATIONS

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The modified semiempirical (MSE) method [1,2] developed in Belgrade 22 years ago, proved many times its usefulness for a number of astrophysical problems. In comparison with the full semiclassical approach and the Griem's semiempirical approach who needs practically the same set of atomic data as the more sophysticated semiclassical one, the modified semiempirical approach needs a considerably smaller number of such data, so that it is particularly useful for stellar spectroscopy depending on very extensive list of elements and line transitions with their atomic and line broadening parameters where it is not always possible to use more sophysticated theoretical approaches. Moreover, in the case of more complex atoms or multiply charged ions the lack of the accurate atomic data needed for more sophysticated calculations, makes that the reliability of the semiclassical results decreases. In such cases the MSE method might be very interesting as well.

The modified semiempirical method and Stark broadening parameters calculated within this approach have been applied in astrophysics e.g. for the determination of carbon, nitrogen and oxygen abundances in early B-type stars, magnesium, aluminium and silicon abundances in normal late-B and HgMn stars from co-added IUE spectra, elemental abundances in hot white dwarfs, investigations of abundance anomalies in stars, elemental abundance analyses with DAO spectrograms for 15 - Vulpeculae and 32 - Aquarii , radiative acceleration calculation in stellar envelopes, consideration of radiative levitation in hot white dwarfs, quantitative spectroscopy of hot stars, non - LTE calculations of silicon - line strengths in B - type stars, stellar opacities calculations and study, atmospheres and winds of hot stars investigations and investigation of Ga II lines in the spectrum of Ap stars. Stark broadening data calculated within the modified semiempirical method entered in a critical overview of atomic data for stellar abundance analysis, and a catalogue of atomic data for low-density astrophysical plasma. The modified semiempirical method entered also in computer codes, as e. g. OPAL opacity code, handbooks and monographs.

In this review we present an analysis of the use of the MSE method in astrophysics, as well as the results of our analyses of the influence of |Stark broadening effect on particular spectral lines in stellar atmospheres, with the particular emphasys on chemically peculiar (CP) stars.

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THE MICROLENSING INFLUENCE ON AGN SPECTRAL LINE SHAPES: FROM X-RAY TO THE OPTICAL WAVELENGTH RANGE

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It is well known that Active Galactic Nuclei (AGNs) are powerful sources of radiation, and that they emit spectral lines from X-ray (Fe K-alpha) to the optical wavlength range. These lines are very interesting to study the physical conditions as well as the kinematical properties of the emitting gas. We have studied the influence of gravitational microlensing on the AGN spectral line shapes [1-4] taking into account recent determinations of the size of the Broad Line Region (BLR). We found that microlensing by a star in a foreground (lens) galaxy can be significant in the optical and X-ray lines of multiple-imaged QSOs. In the case of the Fe K lines, microlensing may be also induced by stars in the bulge of the QSO host galaxy. The microlensing effect in the innermost region of the accretion disc (Fe K-alpha line) is different for Kerr and Schwarczshild metric, what could be an interesting method to check the rotation of a central Black Hole.

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STARK BROADENING EFFECT ON Si I 6155 A LINE IN STELLAR ATMOSPHERES

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INTRODUCTION

The Stark broadening mechanism for A and B type stars is the most signitificant pressure broadening mechanism, and one has to take into account this effect for investigations, analysis and modeling of such stellar atmospheres. In one of our previous work [1] we have obtained that neglecting this mechanism, we introduce an error between 10% and 45% in the equivalent width determination, and corresponding errors in abundance determination. On the other hand, high resolution spectra allow us to study different effects using line profiles. During the abundance analyses of peculiar Ap stars we notified that some of the Si I lines are shifted with respect to the laboratory wavelength. Moreover, few strong lines manely from the multiplets $3p^3\,{}^3D_0$-$5f^3D$ and $3p^3D_0$-$5f^3G$ have assymmetrical line profile, in particular line Si I 6155.13 and 6142.48 A . We have found that these lines are slightly shifted and asymmetrical even in the Solar spectrum, while in the hotter, e.g. Ap stars, the shift and asymmetry are more noticeable.

In this paper we present our investigations of Stark broadening influence on Si I 6155.13 A in Ap star 10 Aql. First we have calculated the Stark broadening parameters for this line, and after that we use a code to fit the line.

THE STARK BROADENING PARAMETERS CALCULATION AND SYNTHEZIS LINE PROCEDURE

Calculations have been performed within the semiclassical perturbation formalism, developed and discussed in detail in [2,3]. This formalism, as well as the corresponding computer code, have been optimized and updated several times [4-6]. The atomic energy levels needed for Stark broadening calculations were taken from Martin and Zalubas [7], but LS determination of $5f^3D$, $5f^3G$, $6s^1P_0$ and $7s^1P_0$ terms have been adopted according to Moore [8]. Oscillator strengths have been calculated by using the method of Bates and Damgaard [9] and tables of Oertel and Shomo [10]. For higher levels, the method described in [11] has been applied. For perturber densities lower than those tabulated here, Stark broadening parameters vary linearly with perturber density. Nonlinear behaviour of Stark broadening parameters on higher densities is the consequence of the influence of Debye shielding and has been analyzed in detail in [5].

The calculation of model atmosphere as well as calculation of absorption coefficients were made under assumption of LTE (Local Thermodynamical Equilibrium). We used ATLAS9 code written by R.L. Kurucz [12] for model calculation with parameters T_{eff} = 7550K, log$g$ = 4.0 and solar abundance (T_{eff} is the effective temperature, g is the surface gravity) . Next step is the calculation of outward flux radiation at corresponding wavelenghts points using the given model. For this purposes we used STARSP program written by V.V. Tsymbal [13]. To describe qualitative differences between theory and observation we have included in this code a possibility of synthetic spectrum computation when stratification of chemical elements takes place.

RESULTS

Our results for electron-, proton-, and ionized helium-impact line widths and shifts for Si I 6155.13 A spectral line for perturber density of 10^{14} cm^{-3} and temperatures T=2,500 - 50,000 K, are shown in Table 1.

As was discussed before, the asymmetry and shift of Si I 6142.48 A and 6155.13 A lines were observed, and it was obvious that the asymmetry is higher for the hotter stars. Taking into account that Stark broadening effect should be dominant in hotter stars [1] we have synthesysed the Si I 6155.13 A lines including calculated Stark broadening parameters.

In Fig. 1, the comparison between calculated (solid line) and observed (dots) Si I 6155.13 A line profile of Ap star 10 Aql is presented. In Fig 1a the comparison is given when in the model only stratification effect was taken into account, in Fig 1b the fit when only Stark broadening effect is taken account is shown, and in Fig 1c one can see the comparison of calculated line profile when both – Stark broadening effect and stratification are taken into account

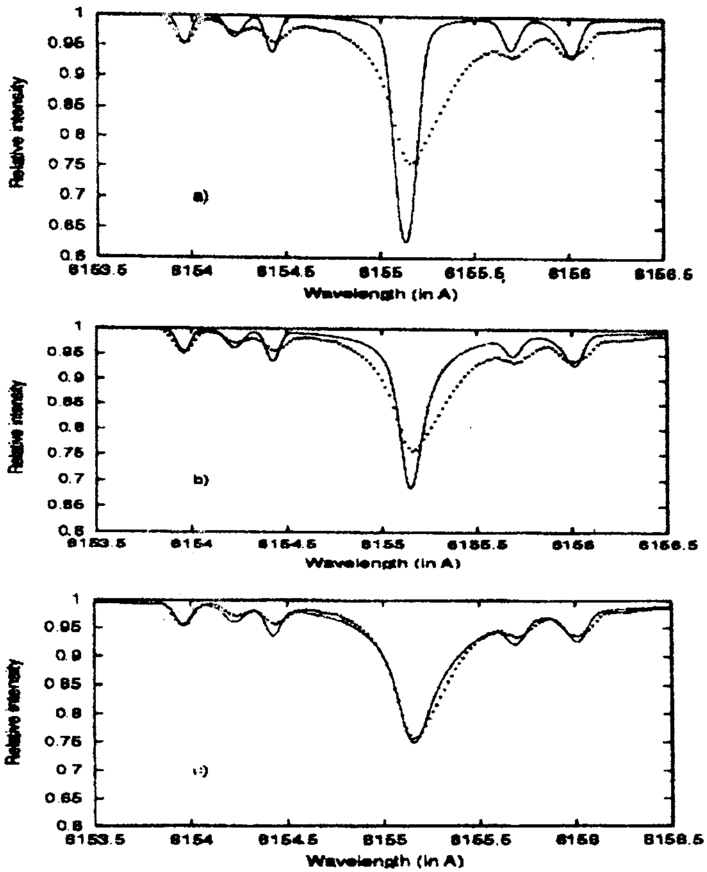

Fig 1. Comparison of calculated (solid line) and observed (dots) profile of Si I 6155.13 A

TABLE 1. *Stark Broadening Parameters for Si I 6155.13 A spectral line. This table shows electron-, proton-, and ionized helium-impact broadening parameters for Si I for perturber density of 10^{14} cm^{-3} and temperatures from 2,500 up to 50,000 K. FWHM(A) denotes full line width at half maximum in A , while SHIFT denotes line shift in A . A positive shift is toward red.*

		ELECTRONS		PROTONS		HELIUM IONS	
TRANSITION	T(K)	FWHM(A)	SHIFT(A)	FWHM(A)	SHIFT(A)	FWHM(A)	SHIFT(A)
SiI $3p^3$-5f	2500.	0.831E-01	-0.591E-01	0.176E-01	-0.146E-01	0.146E-01	-0.115E-01
$^3D_3$-$^3G_4$	5000.	0.916E-01	-0.644E-01	0.196E-01	-0.169E-01	0.161E-01	-0.135E-01
6155.13 A	10000.	0.102	-0.616E-01	0.219E-01	-0.194E-01	0.179E-01	-0.155E-01
	20000.	0.110	-0.446E-01	0.245E-01	-0.220E-01	0.199E-01	-0.177E-01
	30000.	0.118	-0.360E-01	0.261E-01	-0.237E-01	0.212E-01	-0.191E-01
	50000.	0.125	-0.281E-01	0.285E-01	-0.260E-01	0.230E-01	-0.209E-01

From the obtained results we can conclude that: 1) The Stark broadening effect is very important for the considered line. The contribution of electron impact broadening is dominant, but, impacts with protons and He II ions should be also taken into account.; 2) The asymmetry as well as the shift of Si I 6155.13 A line in hot star spectra (as e.g. on ro Ap 10 Aql spectrum) can be explained by Stark broadening effect; 3) In hotter Ap stars, beside Stark broadening effect, the stratification play very important role in line width, consequently it should be taken into account together with Stark broadening effect.

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On Stark Widths of Ar I Lines in the Optical Part of the Spectrum

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Abstract. Stark widths of six Ar I spectral lines in the optical part of the spectrum, corresponding to the $3p^5nd \rightarrow 3p^54p$ (n = 7-5) and $4p' \rightarrow 4s$ transitions, were calculated using the semi-classical perturbation approach. The obtained results were compared with other theoretical and experimental data.

Keywords: Stark broadening, Line broadening, Plasma diagnostics.
PACS: 95.30.Dr, 32.70.Jz

CALCULATIONS

Using the semi-classical perturbation formalism within the impact approximation [1-3], Stark broadening of argon lines in the visible part of the spectrum,

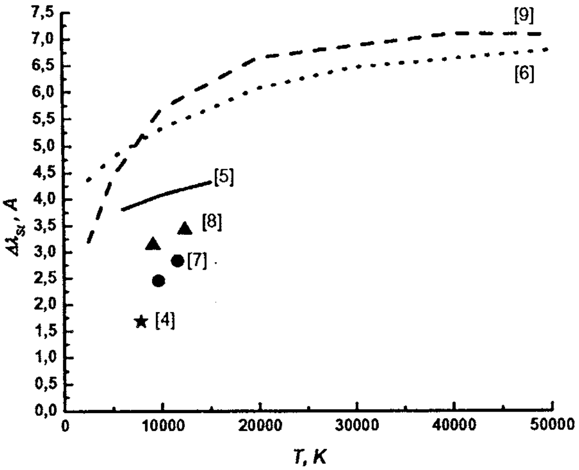

FIGURE 1. Stark full widths at half maximum of Ar I 549.6 nm versus the temperature: theoretical and experimental values are normalized to the electronic density of 10^{16} cm^{-3}.

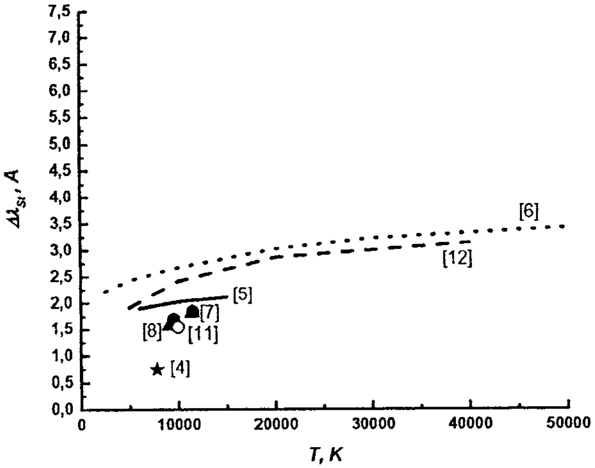

FIGURE 2. Stark full widths at half intensity maximum of Ar I 603.2 nm versus the temperature: theoretical and experimental values are normalized to the electronic density of 10^{16} cm^{-3}.

corresponding to the $3p^5nd \rightarrow 3p^54p$ (n = 7-5) and $4p' \rightarrow 4s$ transitions have been calculated for temperatures within the (2.5-5.0) x10^4 K range and for a perturber density of 10^{14} cm^{-3}. All data concerning to the used method and to the details of calculations will be published elsewhere. Some preliminary results with basic explanations are presented in Refs. [5, 6, 10]. Here, the obtained results will be compared with other theoretical and experimental data. We note here that our results in Refs. [5] and [10] are for a particular line within a multiplet and from Ref. [6] for a multiplet.

RESULTS AND DISCUSSION

In Figs.1-2 our calculations of the Stark widths of argon 549.6 and 603.2 nm spectral lines in pure argon gas are compared with those, published by Griem [9, 12] and with the available experimental ones.

In Table 1 we compare our Stark width results with other theoretical and experimental ones. The corresponding experimental conditions and references for all studied spectral lines are given as well.

One can see that the agreement with the experimental data is better for the calculations for a particular line than for the multiplet as a whole. Obtained theoretical results are in good agreement with ones from Refs. [9,12] but lower. Theoretical Stark widths, obtained here as well as from Refs. [9,12] are higher than experimental ones.

TABLE 1. Experimental and theoretical Stark broadening.

λ, nm	$n_e.10^{16}$, cm^{-3}	T, K	$\Delta\lambda^{th}$, A°	$\Delta\lambda^{exp}$, A°	Ref.
522.1	1.0	7800		3.18	[4]
	1.0	10 000	8.16		[5]
	1.0	10 000	9.92		[6]
549.6	1.1÷5.3	9650÷11600		2.7÷15.0	[7]
	0.63÷7.3	9100÷12350		1.97÷25.0	[8]
	1.0	7800		1.68	[4]
	1.0	10 000	5.68		[9]
	1.0	10 000	4.08		[5]
	1.0	10 000	5.31		[6]
518.8	0.63÷4.7	9100÷11450		1.26÷11.0	[8]
	1.0	7800		1.09	[4]
	1.0	10000	1.77		[10]
603.2	1.0÷5.0	9550÷11500		1.7÷9.2	[7]
	0.63÷4.7	9100÷11450		0.98÷8.55	[8]
	1.0	7800		0.75	[4]
	1.6	10 000		2.47	[11]
	1.0	10 000	2.41		[12]
	1.0	10 000	2.02		[10]
	1.0	10 000	2.67		[6]
560.7	0.63÷7.3	9100÷12400		0.77÷9.43	[8]
	1.0	7 800		0.72	[4]
	1.0	10 000	1.38		[10]
696.5	1.2÷6.0	9700÷11800		0.14÷0.63	[13]
	14.5	13 800		0.80	[14]
	4.8 ÷ 19.6	1e4 ÷ 2e4		0.40 ÷ 1.40	[15]
	1.2 ÷ 7.7	9700÷12250		0.08 ÷ 0.66	[16]
	10.0	13 000		0.81	[11]
	60 ÷ 100	1.65÷1.87e4		4.4 ÷ 6.5	[17]
	6.0	11 900		0.4	[18]
	3.3	13 000			[19]
	10.0	13 000		0.814	[20]
	3.8	13 000		0.33	[21]
	5.5	17 000			[19]
	10.0	1.35÷2.65e4		0.97	[22]
	3.8	13 000		0.33	[21]
	10.0	15 660		1.07	[23]
	6.7	15 6000		0.519	[24]
	7.0	16 000		0.58	[24]
	7.1	16200		0.57	[24]
	12.1-19.7	13.5-24.0e3		1.18-1.85	[20]
	10	12750		0.8	[25]
	20-10	14.0-12.0e3		1.4-0.8	[26]
	57-80	16.8-19.0e3		3.9-5.1	[27]
	1.0	10 000	11.34e-2		[9]
	1.0	10 000	8.57e-2		[21]
	1.0	10 000	8.86e-2		[5]

ACKNOWLEDGMENTS

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES and PROGRESS REPORTS

Editors

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Belgrade, 2006

On Stark Broadening Parameters for Se III Lines in Laboratory and Stellar Plasma

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Abstract. Using the modified semiempirical approach, Stark widths for three Se III transitions were calculated. For these lines, the full semiclassical perturbation approach is not applicable in an adequate way due to the lack of reliable atomic data. Results are obtained as a function of temperature, for perturber density of 10^{17} cm^{-3}. Obtained results are used for an analysis of the influence of Stark broadening for A type star and DB white dwarf atmospheres conditions.

INTRODUCTION

With the development of new techniques, importance of data on trace element spectra like Se increases. Also, the knowledge of Stark broadening parameters is of interest for the investigation of laboratory and technological plasmas.

Selenium, a trace element without an astrophysical significance before, is now detected in the atmospheres of cool DO white dwarfs [1,2].

Here we present Stark widths for three transitions of Se III calaculated by using the modified semiempirical approach [3,4]. Obtained theoretical results are used here to consider the influence of Stark broadening on spectral line shapes for A type stars and DB white dwarf atmospheres conditions

RESULTS AND DISCUSSIONS

Atomic energy levels needed for calculation of Se III Stark line widths were taken from [5].

The results obtained within the modified semiempirical method ([3]; see also the review of inovations and applications in [4]) for the Stark widths (full width at half maximum) due to electron-impacts, for three Se III transitions are shown in Tables 1 respectively for perturber density of 10^{17} cm^{-3} and temperatures from 10000 K up to 300000 K.

In Fig. 1, Se III 5s $^3P^o$ - 5p ^3D (λ=3815.5 Å), line widths due to Stark and thermal Doppler broadening mechanisms are compared as functions of Rosseland optical depth corresponding to 10000-30000 K temperature range, for an A type star atmosphere model with T_{eff} = 10000 K and log g = 4.5 [6]. One should take into account that due to differences between Lorentz (Stark) and Gauss (Doppler) line intensity distributions, Stark broadening may be more important on line wings in comparison with the thermal Doppler one, even when it is smaller in the central part.

TABLE 1. This table shows Se III electron-impact broadening parameters (full width at half maximum W) obtained by the modified semiempirical method [3] for perturber density of 10^{17} cm^{-3} and temperatures from 10000 up to 300000 K.

Transition	T(K)	Width(Å)
5s $^3P^o$ - 5p ^3D 3815.5 Å	10000	0.377
	20000	0.267
	50000	0.169
	100000	0.134
	200000	0.119
	300000	0.116
5s $^3P^o$ - 5p ^3P 3534.1 Å	10000	0.321
	20000	0.227
	50000	0.144
	100000	0.113
	200000	0.101
	300000	0.981E-01
5s $^3P^o$ - 5p ^3S 3271.0 Å	10000	0.273
	20000	0.193
	50000	0.122
	100000	0.958E-01
	200000	0.857E-01
	300000	0.831E-01

The influence of the Stark broadening on Se III spectral lines for DB white dwarf plasma conditions was investigated for 5s $^3P^o$ - 5p ^3D (λ=3815.5 Å) by using the corresponding model with T_{eff} = 15000 K and *log* g = 7 up to 9 [7]. For the considered model atmosphere of the DB white dwarfs the prechosen optical depth points at the standard wavelength λ =5150 Å (τ_{5150}) are used in [7] and here, as the difference to the A type star model [6], where the Rosseland optical depth scale (τ_{Ross}) was taken. As one can see in Fig. 2, for the DB white dwarf atmosphere plasma conditions, thermal Doppler broadening has much less importance in comparison with the Stark broadening mechanism.

The Stark broadening parameters obtained here, contribute also to the creation of a set of such data for as large as possible number of spectral lines, of significance for a number of problems in astrophysical, laboratory and technological plasma research.

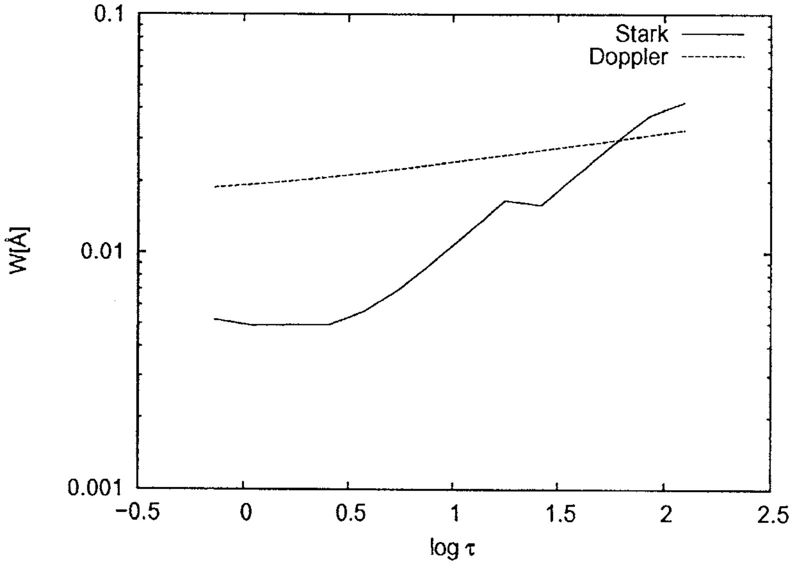

FIGURE 1. Thermal Doppler and Stark widths for Se III spectral lines 5s ^{3}P° - 5p ^{3}D (λ=3815.5 Å), for an A type star atmosphere model with T_{eff} = 10000 K and *log* g = 4.5, as a function of the Rosseland optical depth.

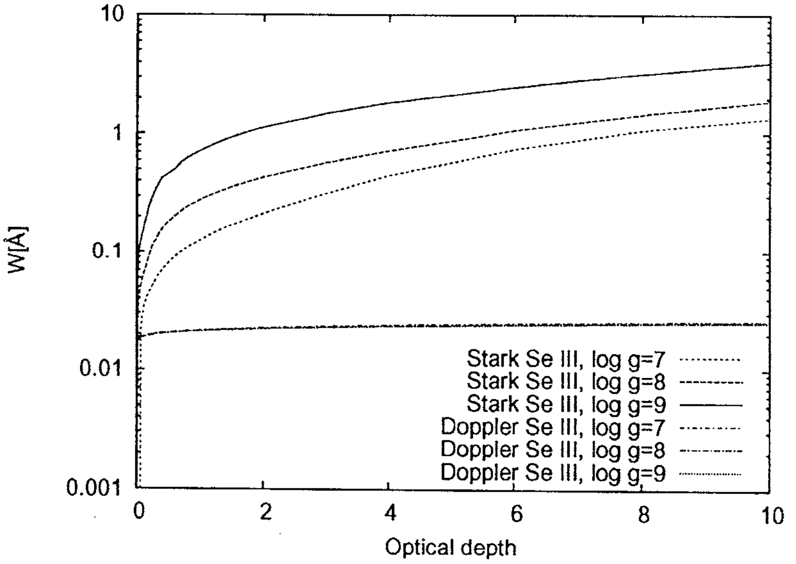

FIGURE 2. Thermal Doppler and Stark widths for Se III spectral lines 5s ^{3}P° - 5p ^{3}D (λ=3815.5 Å), for a DB white dwarf atmosphere model with T_{eff} = 15000 K and *log* g = 7 up to 9, as a function of optical depth τ_{5150}.

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Influence of chemi-ionization and chemi-recombination processes on Hydrogen line shapes in M dwarfs

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Abstract. We study an influence of chemi-ionization and chemi-recombination processes on the population of higher levels and consequently on profiles of Hydrogen lines in the atmospheres of late type (M) stars. Modeling, using general stellar atmosphere code PHOENIX reveals importance of inclusion of such processes.

Keywords: atomic processes - molecular processes - Stars: atmosphere
PACS: 34.70+e, 97.10.Ex

INTRODUCTION

In previous papers [1, 2] we demonstrated the influence of a group of collisional chemi-ionization and chemi-recombination processes on the excited atom populations in Hydrogen plasmas with the ionization degree less than 10^{-3}. We studied the ionization processes

$$H^*(n) + H ---> e + H^+ + A, \quad (1)$$

$$H^*(n) + H ---> e + H_2^+, \quad (2)$$

and correspondent inverse recombination processes

$$e + H^+ + H ---> H^*(n) + H, \quad (3)$$

$$e + H_2^+ ---> H^*(n) + H, \quad (4)$$

where $H = H(1s)$, $H^*(n)$ is the hydrogen atom in the excited state with the principal quantum number n, H_2^+ - the molecular ion in the ground electronic state, and e - free electron.

We applied the same methodology to show the importance of these processes in the Solar atmosphere [3] and atmospheres of cool stars [4]. We compared these processes with the efficiency of the ionization and recombination electron-atom and electron-ion processes

$$e+H^*(n)--->e+H^++H, \quad (5)$$

$$e+e+H^+--->e+H^*(n), \quad (6)$$

$$e+H^+--->\varepsilon_\lambda+H^*(n). \quad (7)$$

where ε_λ denotes the energy of the emitted photon.

Moreover, in [5] we demonstrated the influence of the processes similar to the processes (1) - (4) on the excited atom populations in weakly ionized helium plasma and shown the importance of chemi-ionization and chemi-recombination processes in atmospheres of some DB white dwarfs.

Major result of previous work was that it is very important to include mentioned processes as the population numbers can differ for up to 50% [4].

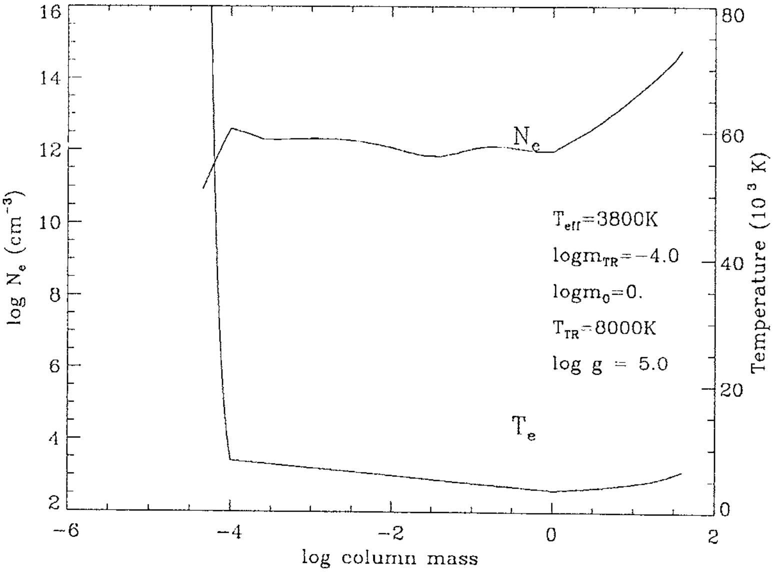

FIGURE 1. Structure of model atmosphere - Temperature and electron density vs column mass

RESULTS OF MODELING AND DISCUSSION

We use the general stellar atmosphere code PHOENIX [6, 7, 8] for our modeling. This code has an advantage that apart for solving the atmospheric structure, it also calculates output spectra, so changes in population levels are reflected on line shapes.

Theory we used in previous work has a shortcoming that it is not applicable for the levels $n \leq 4$. That means that collisional processes are not completely accounted for lower levels of Hydrogen atom. To overcome this problem we introduced in PHOENIX collisional rates from [9].

The procedure similar to one used in [4] was applied. Basic atmosphere has an effective temperature of 3800K, with chromosphere and transition region appearing at logarithm column mass of 0.0 and -4.0 respectevly and temperature at the bottom of transition region fixed at 8000K. This basic atmosphere is shown in Fig.1.

Atmospheric structure was iterated until changes in populations of levels of atomic Hydrogen were less than 1%.

In Figs.2-5 we show the final line profiles of H_α, H_δ, H_ε and $Pa\varepsilon$ with and without inclusion of new processes.

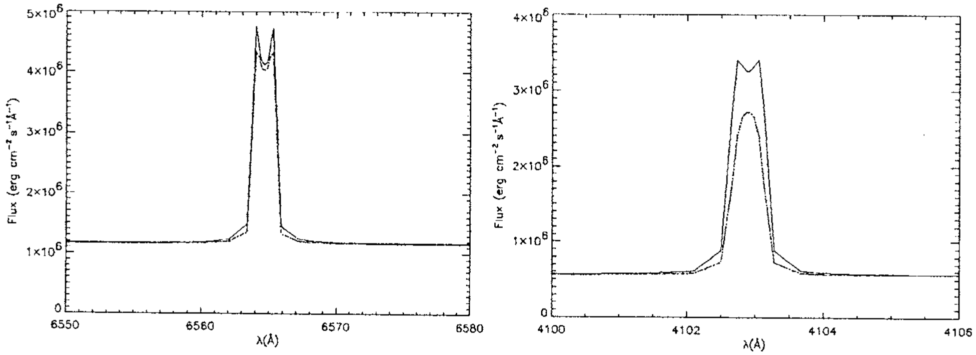

FIGURE 2. Line profiles with (full) and without (dashed) inclusion of chemi-ionization and chemi-recombination processes for H_α (left) and H_δ (right) lines from the atmosphere described in text and shown in Fig. 1

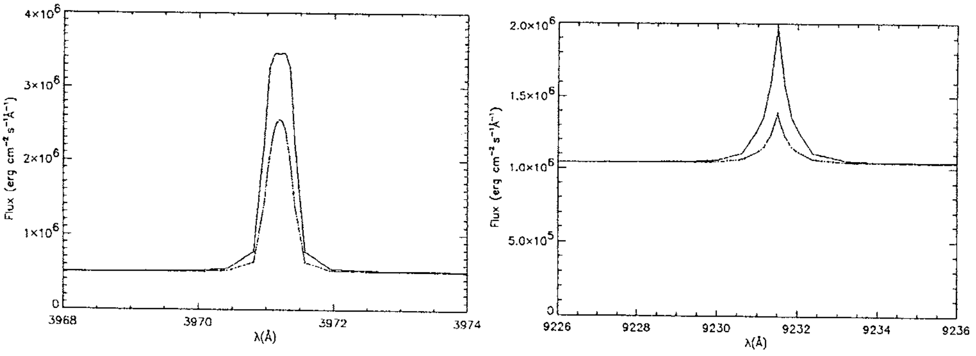

FIGURE 3. Same as in Fig.2 for H_ε and Pa_ε

As one can see there is significant change in line profiles, so it is very important to include chemi-ionization and chemi-recombination processes in modeling of atmospheres of late type stars, especially if one wants to use line profiles as diagnostics of stellar chromospheres.

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Belgrade, 2006

The SACs Broadening

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Abstract. As we know, some spectral lines of many Oe and Be stars present Discrete Absorption Components (DACs) or Satellite Absorption Components (SACs). The presence of SACs can broaden the spectral line and we call this phenomenon SACs broadening. The recently published Gaussian-Rotation model enables to study many parameters of the regions that construct this kind of spectral lines. In this paper we indicate that we can detect the same phenomena in the spectra of many quasars and that we can study them with this method.

Keywords: Hot emission stars, quasars, models, DACs, SACs.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh, 98.54.Aj

INTRODUCTION

Into a stellar atmosphere or a disc that exist around hot emission stars, an absorption line can originate from several regions that present the same temperature. From each of these regions an absorption component arises.

The line profile of each of these absorption components is a function of a group of physical parameters, as the radial, the rotational, the random velocities and the optical depth of the region that produce the specific components of the spectral line.

These spectral lines are named Discrete Absorption Components (DACs), if they are discrete [1].

DACs are discrete but not unknown absorption spectral lines. They are spectral lines of the same ion and the same wavelength as a main spectral line, shifted at different , as they are created in different density regions which rotate and move radially with different velocities [2,3].

In this paper we indicate the existence of the DACs phenomenon in the spectra of some quasars. We propose that a similar phenomenon, which we call SACs phenomenon, is one of the reasons of the broadening and the complex structure of the observed spectral lines of hot emission stars and quasars.

THE DACs PHENOMENON IN QUASARS

DACs are lines, easily observed, when the regions that give rise to such lines, rotate with low velocities and move radially with high velocities.

In Fig. 1 we can see the Mg II doublet in the UV spectrum of HD 45910. In these line profiles we can see the main spectral lines and a group of DACs at the blue side of each one of them. Below the spectra we can see the components that create the observed features.

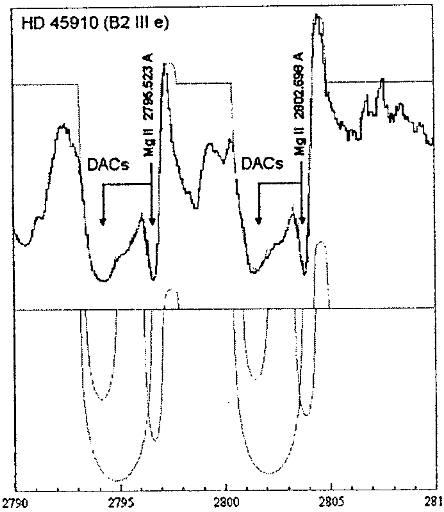

FIGURE 1. Presence of DACs in the Mg II resonance lines of the Be star HD 45910.

It is very important to point out that we can detect the same phenomenon in the spectra of many quasars. In Fig. 2 we can see the C IV doublet of the quasar PG 0946+301. The values of radial displacements and the ratio of the line intensities indicate that the two observable C IV features present a similar DACs phenomenon as in the case of the spectra of hot emission stars.

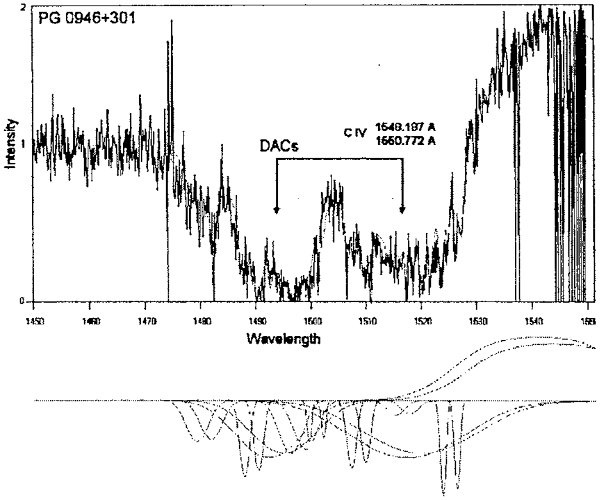

FIGURE 2. Presence of DACs in the C IV resonance lines of the quasar PG 0946+301.

THE SACs BROADENING

However, if the regions that give rise to such lines, rotate with large velocities and move radially with small velocities, the produced lines have large widths and small shifts.

As a result they are blended among themselves as well as with the main spectral line and thus they are not discrete. In such a case the name Discrete Absorption Components is inappropriate and we use only the name Satellite Absorption Components (SACs) [2,3]. The present of SACs can broaden the line shape and we call this phenomenon SACs broadening.

In Fig. 3 we observe the SACs phenomenon in the doublet of Mg II in the case of the Be star HD 41335. Below the spectra we can see the components that create the observed features.

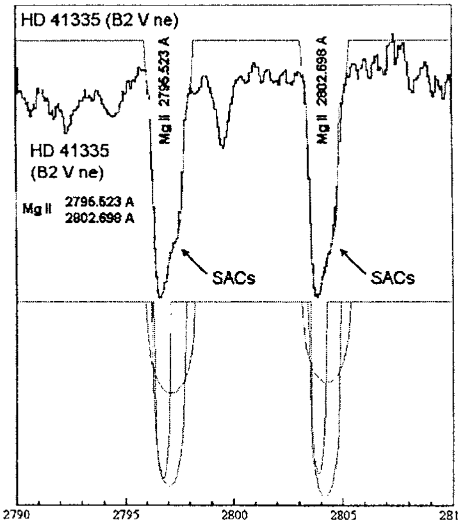

FIGURE 3. Presence of SACs in the Mg II resonance lines of the Be star HD 41335

As we know, around the hot emission stars and the quasars we can detect extensive disc. However, the disc model is not able to reproduce the profiles of many spectral lines.

The question that we examine is the possibility to explain the very complex structure of the spectral lines in many quasars, using the SACs phenomenon. The first conclusions are very promising.

In Fig. 4 we can see the complex structure of C IV doublet and the Si IV, C IV doublet in the spectra of the quasar PG 1700+518 and H 1413+1143 respectively. Below the spectra we can see the components that create the observed features.

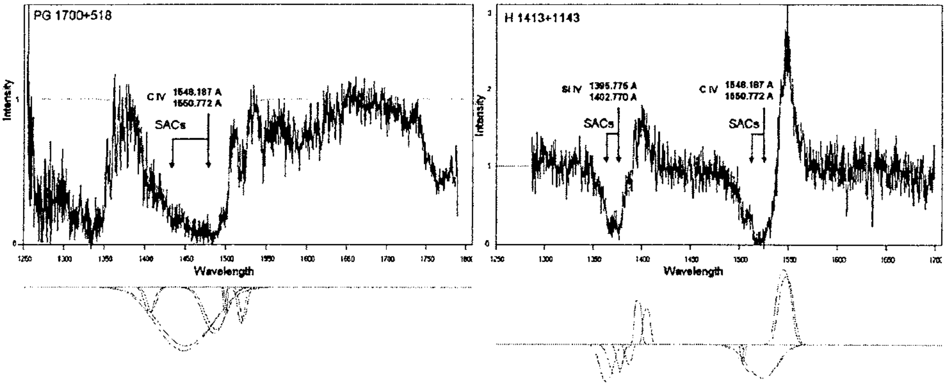

FIGURE 4. Presence of SACs in the C IV resonance lines of the quasar PG 1700+518 and in the Si IV and C IV resonance lines of the quasar H 1413+1143.

CONCLUSIONS

As we see, the presence of SACs can broaden the line shapes and we call this phenomenon SACs broadening. An important point is that we can detect DACs or SACs phenomena not only in the spectra of hot emission stars but also in the spectra of many quasars.

This means that we can study all these line shapes with GR model [4,5].

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science and Environment Protection of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES and PROGRESS REPORTS

Editors

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Belgrade, 2006

The Photospheric And The Respective Si IV Regions' Rotational Velocities In 27 Be Stars

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Abstract. It is known that some spectral lines of many Oe and Be stars present Discrete Absorption Components (DACs) or Satellite Absorption Components (SACs). Recently, we presented a method to study many parameters of the regions that create this kind of spectral lines. In this paper, using this method, we study the relation between the rotational velocities of the Si IV regions of 27 Be stars and their photospheric rotational velocities.

Keywords: Be stars, DACs, SACs, rotational velocity, photospheric rotational velocity.
PACS: 97.10.Ex, 97.10.Fy, 97.10.Kc, 97.20.Ec, 97.30.Eh

INTRODUCTION

A significant phenomenon in the spectra of hot emission stars is the existence of Discrete Absorption Components (DACs) [1] or Satellite Absorption Components (SACs) [2,3].The appearance of these components results to the complex profile of many spectral lines in the spectra of Oe and Be stars. The difference between the DACs and SACs phenomena is explained in [2-6].

In this paper we study the relation between the rotational velocities of the Si IV regions of 27 Be stars and their photospheric rotational velocities, using the method described in [4], where the C IV regions in 20 Oe stars have been analysed. Finally, we compare the results of the Si IV regions of 27 Be stars and the C IV regions in 20 Oe stars.

THE RELATION BETWEEN THE PHOTOSPHERIC AND THE RESPECTIVE Si IV REGIONS ROTATIONAL VELOCITIES OF 27 Be STARS

This study is based on the analysis of 27 Be stellar spectra taken with the IUE - satellite (IUE Database http://archive.stsci.edu/iue). We examine the complex structure of the Si IV resonance lines (1393.755 , 1402.77). Our sample includes all the subtypes from B0 to B8. The values of the photospheric rotational velocities are taken from the catalogue [7].

We found that the Si IV spectral lines consist of three components in 7 stars, four in 15 stars and five in 5 stars. The ratio V_{rot}/V_{phot} of the first to fifth detected components as a function of the photospheric rotational velocity (V_{phot}) is presented in Figs. 1a to 5a, respectively. In such a way we obtain an indication of how much the rotational velocity of the specific Si IV layer is higher than the apparent rotational velocity of the star. In Figs. 1b - 5b the respective ions' random velocities (V_{rand}) are presented as a function of the photospheric rotational velocity, where V_{rot} is the rotational velocity of the successive Si IV regions that form each of the considered components. We observe that the dispersion of the random velocities decreases from the first to the fifth component.

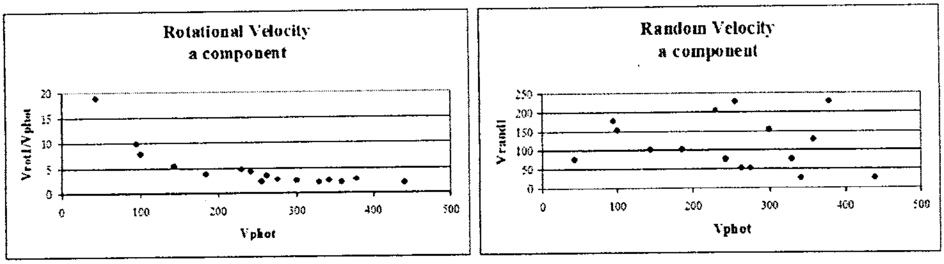

FIGURE 1a, b.: The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} of the first component in the sample of 27 Be stars.

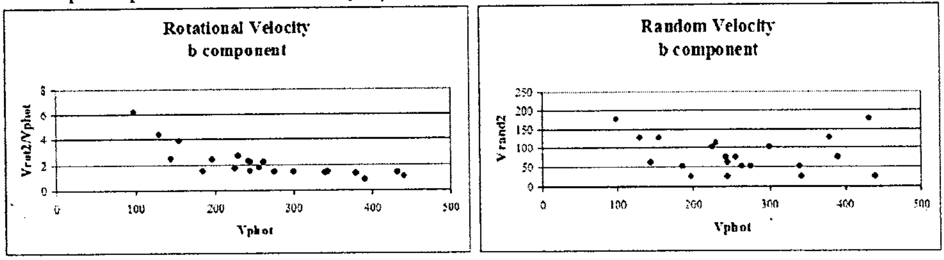

FIGURE 2a, b.: The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the second component in the sample of 27 Be stars.

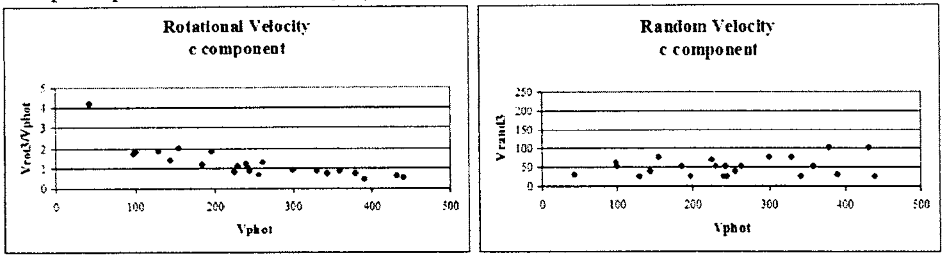

FIGURE 3a, b.: The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the third component in the sample of 27 Be stars.

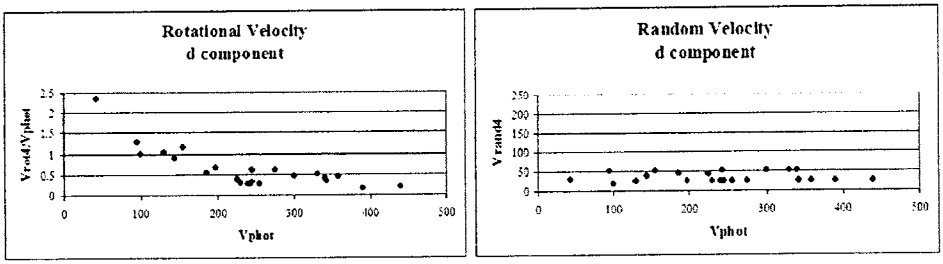

FIGURE 4a, b.: The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the fourth component in the sample of 27 Be stars.

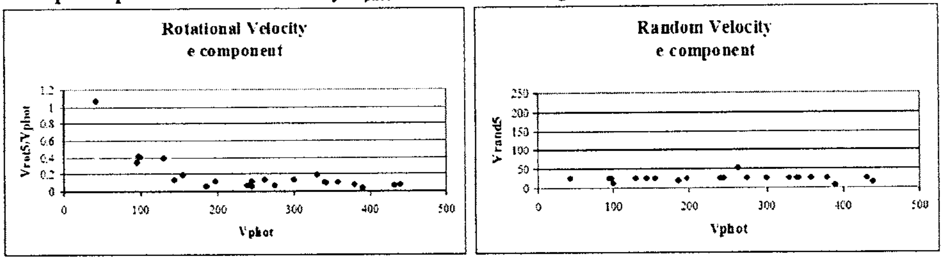

FIGURE 5a, b.: The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the fifth component in the sample of 27 Be stars.

RESULTS

Our results are very similar with the ones extracted from the study of the C IV regions in 20 Oe stars [4]. The Si IV resonance lines are composed of three four of five components, depending on the star. This means that there exist three to five independent density regions responsible for the creation of these components. The difference with the case of the C IV resonance lines in the spectra of 20 Oe stars, is that they are composed of two, three or four components. However, in both cases, in each region and for each component there exists a logarithmic relation between the ratio V_{rot}/V_{phot} and the photospheric rotational velocity V_{phot}. For the satellite components of the Si IV resonance lines, the maximum ratio V_{rot}/V_{phot} varies from 19, for the first to 1 for the fifth component (Figs. 1a - 5a). The same phenomenon appears in the case of the C IV resonance lines in 20 Oe stars, where the maximum ratio V_{rot}/V_{phot} varies from 40, for the first to 5 for the fourth component [4].This variation may be due to the inclination of the stellar axis. In order to test the validity of our model we check, for all the studied stars, whether the ion's random velocities of each Si IV component, are constant and do not depend on this angle, as it is theoretically expected. Our results confirm this phenomenon, meaning that the mean values of the ions' random velocities are almost constant (Figs. 1b, 2b, 3b, 4b, 5b). The same results are also extracted from the study of the C IV regions in 20 Oe stars [4].

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science and Environment Protection of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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The Photospheric And The Respective C IV Regions' Rotational Velocities In 20 Oe Stars

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Abstract. It is known that some spectral lines of many Oe and Be stars present Discrete Absorption Components (DACs) or Satellite Absorption Components (SACs). Recently, we developed a method to study many parameters of the regions that create this kind of spectral lines. Using this method, we study here the relation between the rotational velocities of the C IV regions of 20 Oe stars and their photospheric rotational velocities.

Keywords: Oe stars, DACs, SACs, rotational velocity, photospheric rotational velocity.
PACS: 97.10.Ex, 97.10.Fy, 97.10.Kc, 97.20.Ec, 97.30.Eh

INTRODUCTION

As it is already known, some of the spectral lines of many Oe and Be stars present Discrete Absorption Components (DACs) which, due to their profiles' width as well as the values of the radial velocities, create a complex profile of the spectral lines [1]. The DACs are not unknown absorption spectral lines, but spectral lines of the same ion and the same wavelength as a main spectral line, shifted at different , as they are created at different density regions which rotate and move radially with different velocity [2,3].

However, if the regions that give rise to such lines rotate with large velocities and move radially with small velocities, the produced lines have large widths and small shifts. As a result, they are blended among themselves as well as with the main spectral line and thus they are not discrete. In such a case the name Discrete Absorption Components is inappropriate and we use only the name SACs (Satellite Absorption Components). We presented a model able to reproduce the complex profile of DACs or SACs and a method to study many parameters of the regions that create this kind of spectral lines [2,3].

In this paper, using the proposed method [2-5] and, using I.U.E - spectra we study the relation between the rotational velocities of the C IV regions of 20 Oe stars and their photospheric rotational velocities.

THE GAUSSIAN-ROTATIONAL MODEL (GR-MODEL)

Using GR model [2-5] we can calculate many parameters of the regions that create spectral lines which present DACs or SACs, as the apparent rotational and radial velocities, the Gaussian deviation of the ions' random motions, the random velocities of these motions, as well as the optical depth, the Full Width at Half Maximum (FWHM), the absorbed and the emitted energy and the product of the Source function S and the optical depth of the independent regions of matter, which produce the main line and the discrete or satellites components (DACs, SACs) of the studied spectral lines.

THE RELATION BETWEEN THE PHOTOSPHERIC AND THE RESPECTIVE C IV REGIONS ROTATIONAL VELOCITIES OF 20 Oe STARS

This study is based on the analysis of 20 Oe stellar spectra taken with the IUE – satellite (IUE Database http://archive.stsci.edu/iue). We examine the complex structure of the C IV resonance lines (1548.155 , 1550.774). Our sample includes the subtypes O4 (one star), O6 (four stars), O7 (five stars), O8 (three stars) and O9 (seven stars). The values of the photospheric rotational velocities are taken from the catalogue [6].

In our study we detect that the C IV spectral lines consist of two components in 9 stars, three in 7 stars, four in 3 stars and five in one star. In Figs. 1a, 2a, 3a and 4a we present the ratio V_{rot}/V_{phot} of the first, second, third and fourth detected component as a function of the photospheric rotational velocity (V_{phot}). This ratio indicates how many times the rotational velocity of the specific C IV layer is higher than the apparent rotational velocity of the star. In Figs. 1b, 2b, 3b and 4b we present the respective ions' random velocities (V_{rand}) as a function of the photospheric rotational velocity, where V_{rot} is the rotational velocity of the successive C IV regions that create each of these components.

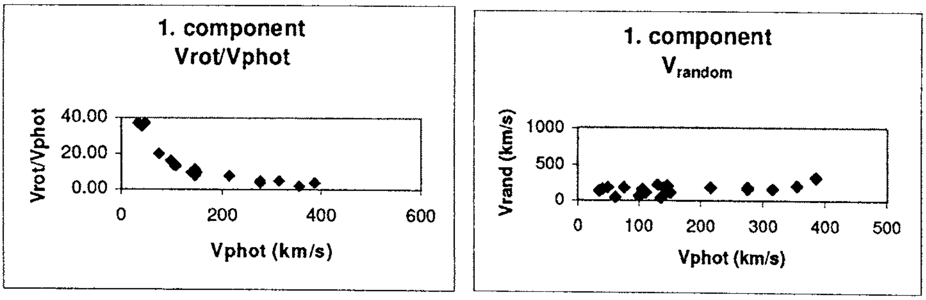

FIGURE 1a, b. The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} of the first component in the sample of 20 Oe stars.

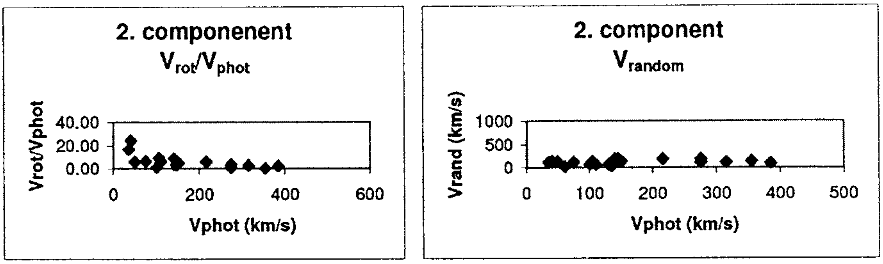

FIGURE 2a, b. The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the second component in the sample of 20 Oe stars.

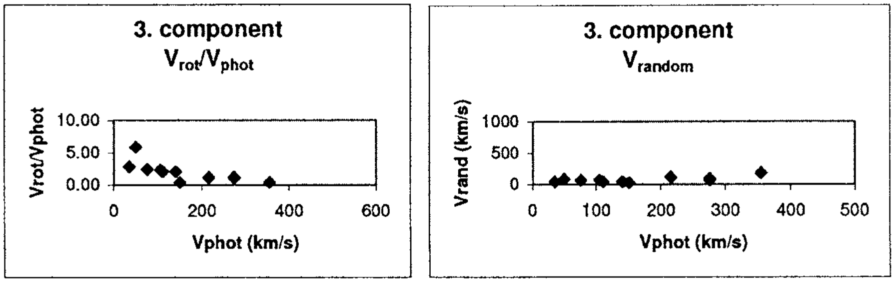

FIGURE 3a, b. The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the third component in the sample of 20 Oe stars.

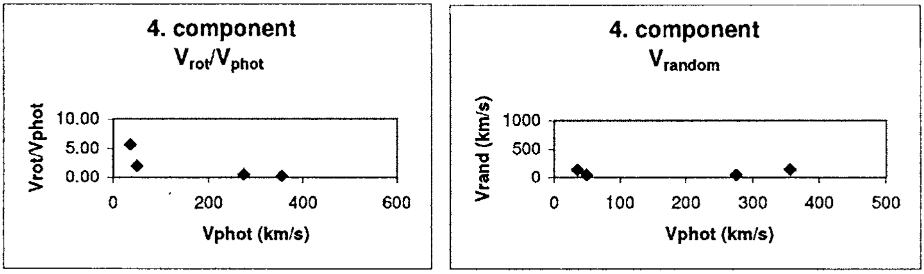

FIGURE 4a, b. The ratio V_{rot}/V_{phot} (left) and the ions' random velocities (right) as a function of the photospheric rotational velocity V_{phot} for the fourth component in the sample of 20 Oe stars.

RESULTS

In each region and for each component we can conclude that there exists a logarithmic relation between the ratio V_{rot}/V_{phot} and the photospheric rotational velocity V_{phot}. The maximum ratio V_{rot}/V_{phot} varies from 40, for the first to 5 for the fourth component (Figs. 1a, 2a, 3a, 4a). A possible explanation of this situation is the inclination of the stellar axis. In order to test the validity of our model we check, for all the studied stars, whether the ion's random velocities of each C IV component, are constant and do not depend on this angle, as it is theoretically expected. Our results confirm this phenomenon, meaning that the mean values of the ions' random velocities are almost constant (Figs. 1b, 2b, 3b, 4b).

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Belgrade, 2006

A Study Of DACs And SACs Regions In The Atmospheres Of Hot Emissions Stars

D. Nikolaidis[1], E. Danezis[1], E. Lyratzi[1], L. . Popovi [2], A. Antoniou[1]
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Abstract. The presence of Discrete Absorption Components (DACs) or Satellite Absorption Components (SACs) is a very common phenomenon in the atmospheres of hot emission stars and their result is the complex line profiles of these stars. The shapes of these lines are interpreted by the existence of two or more independent layers of matter nearby a star. These structures are responsible for the formation of a series of satellite components for each spectral line. Here we present a model reproducing the complex profile of the spectral lines of Oe and Be stars which psesent the DACs and SACs phenomenon. Generally, this model gives a line function for the complex structure of the spectral lines that present DACs or SACs. This line function includes a function L that considers the kinematics (geometry) of an independent region. In the calculation of the function L we have considered the rotational velocities of the independent regions, as well as the random velocities within them. This means that the function L is a synthesis of the Rotation distribution and a Gaussian one. Finally, with this method we can calculate the optical depth ( ) and the column density (d) of each independent density region.

Keywords: Hot emission stars, models, DACs.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh

INTRODUCTION

One of the most important phenomena in the spectra of hot emission stars is the DACs (Discrete Absorption Components) phenomenon [1].

DACs are discrete but not unknown absorption spectral lines. They are spectral lines of the same ion and the same wavelength as a main spectral line, shifted at different , as they are created in different density regions which rotate and move radially with different velocities [2,3]. DACs are lines, easily observed, when the regions that give rise to such lines, rotate with low velocities and move radially with high velocities. However, if the regions, that give rise to such lines, rotate with large velocities and move radially with small velocities, the produced lines are quite broadened but have small shifts. As a result they are blended among themselves as well as with the main spectral line and thus they are not discrete. In such a case the name Discrete Absorption Component is inappropriate and we use only the name SACs (Satellite Absorption Components) [4,5].

DESCRIPTION OF THE MODEL

The Line Profile Function

Some years ago our research team proposed a new model to explain the complex structure of the density regions of hot stars, where the spectral lines that present SACs or DACs are created [2,3].

The main hypothesis of this model is that the atmospherical region where a specific line is created is not continuous, but it is composed of a number of successive independent absorbing density regions, a number of emission regions and an external general absorption region.

By solving the radiation transfer equations through a complex structure, as the described one, we conclude to a function for the line profile, able to give the best fit for the main spectral line and its Satellite Components in the same time (Eq. 1).

$$I_\lambda = \left[I_{\lambda 0} \prod_i e^{-\tau_{ai}} + \sum_j S_{\lambda ej}\left(1 - e^{-\tau_{ej}}\right) \right] e^{-\tau_g} \qquad (1)$$

where: I_0: is the initial radiation intensity, S_{ej} is the source function, which, at the moment when the spectrum is taken, is constant and $e^{-\tau_{ai}}$, $S_{\lambda ej}\left(1 - e^{-\tau_{ej}}\right)$, $e^{-\tau_g}$ are the distribution functions of the absorption, emission and general absorption lines, respectively. This function I does not depend on the geometry of the regions which create the observed feature.

The Spherical Symmetry Hypothesis

In order to include in Eq. (1) some kinematical parameters such as the rotational and the radial velocities, we have to suppose a geometrical hypothesis. If we choose the spherical symmetry hypothesis, Eq. (1) becomes:

$$I_\lambda = \left[I_{\lambda 0} \prod_i e^{-L_{ai}\xi_{ai}} + \sum_j S_{\lambda ej}\left(1 - e^{-L_{ej}\xi_{ej}}\right) \right] e^{-L_g \xi_g} \qquad (2)$$

where: I_0: is the initial radiation intensity, L_{ai}, L_{ej}, L_g: are the distribution functions (Rotation distribution) of the absorption coefficients k_{ai}, k_{ej}, k_g, respectively and is the optical depth in the center of the line.

In the present work we propose an approach of the problem, where we calculate L as a function of the rotational and the random velocities (see [4,5]).

Calculation Of The New Distribution Function (Gauss-Rotation)

Let us consider a spherical shell moving radially and a point A_i in its equator (see Fig. 1a). If the laboratory wavelength of a spectral line that arises from A_i is ${}_{lab}$, the observed wavelength will be ${}_{0} = {}_{lab} + {}_{rad}$ where ${}_{rad}$ is the radial displacement.

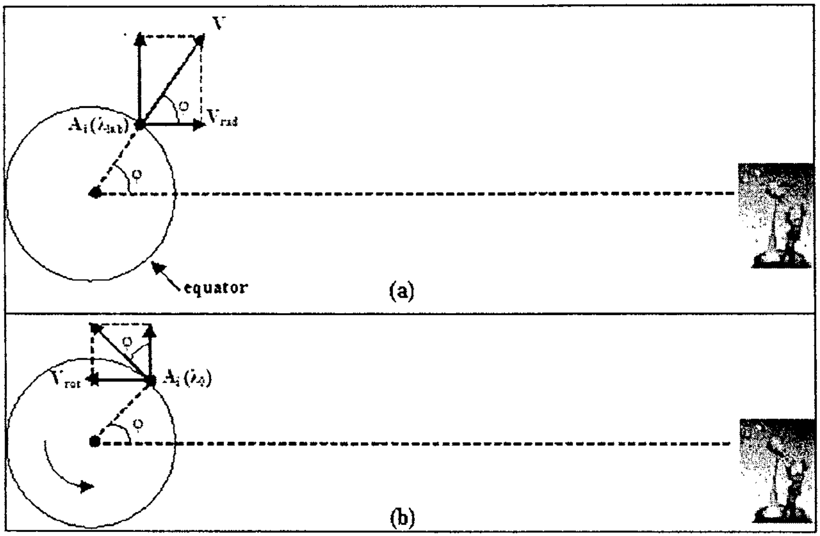

FIGURE 1. View of the equator of a blob. We can see the radial velocity (V_{rad}) of the point A$_i$, which results to the radial displacement ($_{rad}$) (a) and the rotational velocity (V_{rot}) which results to the width ($_{rot}$) (b).

If the spherical density region rotates (see Fig. 1b), we will observe a displacement $_{rot}$ and the new wavelength of the center of the line $_i$ is $\lambda_i = \lambda_0 \pm \Delta\lambda_{rot}$, where $\Delta\lambda_{rot} = \lambda_0 z \sin\varphi$ · and $z = \frac{V_{rot}}{c} = \frac{\Delta\lambda_{rot}}{\lambda_0 \sin\varphi}$, where V_{rot} is the observed rotational velocity of the point A$_i$.

This means that $\lambda_i = \lambda_0 \pm \lambda_0 z \sin\varphi = \lambda_0(1 \pm z\sin\varphi)$ and if $-\frac{\pi}{2} < \varphi < \frac{\pi}{2}$ then $\lambda_i = \lambda_0(1 - z\sin\varphi)$.

If we consider that the spectral line profile is a Gaussian distribution we have: $P(\lambda) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\left[\frac{\lambda-\kappa}{\sigma\sqrt{2}}\right]^2}$ where is the mean value of the distribution and in the case of the line profile it indicates the center of the spectral line that arises from A$_i$. This means that $P(\lambda) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left[\frac{\lambda-\lambda_0(1-z\sin\varphi)}{\sigma\sqrt{2}}\right]^2} = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{[\lambda-\lambda_0(1-z\sin\varphi)]^2}{2\sigma^2}}$. For all the semi-equator we have $L(\lambda) = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{[\lambda-\lambda_0(1-z\sin\varphi)]^2}{2\sigma^2}} \cos\varphi d\varphi$. If we make the transformation $\sin\varphi = x$ and $u = \frac{\lambda - \lambda_0(1-zx)}{\sqrt{2}\sigma}$, then $L(\lambda) = \frac{1}{\lambda_0 z\sqrt{\pi}} \int_{\frac{\lambda-\lambda_0(1+z)}{\sigma\sqrt{2}}}^{\frac{\lambda-\lambda_0(1-z)}{\sigma\sqrt{2}}} e^{-u^2} du$ or

$$L(\lambda)=\frac{1}{\lambda_0 z\sqrt{\pi}}\left[\int_0^{\frac{\lambda-\lambda_0(1-z)}{\sigma\sqrt{2}}} e^{-u^2}du-\int_0^{\frac{\lambda-\lambda_0(1+z)}{\sigma\sqrt{2}}} e^{-u^2}du\right]$$

and $L(\lambda)=\frac{\sqrt{\pi}}{2\lambda_0 z}\left[erf\left(\frac{\lambda-\lambda_0(1-z)}{\sqrt{2}\sigma}\right)-erf\left(\frac{\lambda-\lambda_0(1+z)}{\sqrt{2}\sigma}\right)\right]$.

The distribution function from the semi-spherical region is

$$L_{final}(\lambda)=\frac{\sqrt{\pi}}{2\lambda_0 z}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\left[erf\left(\frac{\lambda-\lambda_0}{\sqrt{2}\sigma}+\frac{\lambda_0 z}{\sqrt{2}\sigma}\cos\theta\right)-erf\left(\frac{\lambda-\lambda_0}{\sqrt{2}\sigma}-\frac{\lambda_0 z}{\sqrt{2}\sigma}\cos\theta\right)\right]\cos\theta d\theta \quad (3)$$

(Method Simpson).

Eq. (3) gives the final distribution function, which is a synthesis of the Rotation distribution and a Gaussian one.

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science and Environment Protection of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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23^{rd} Summer School and International Symposium on the Physics of Ionized Gases

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CONTRIBUTED PAPERS

&

ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES and PROGRESS REPORTS

Editors

Nenad S. Simonović, Bratislav P. Marinković and Ljupčo Hadžievski

Institute of Physics
Belgrade, Serbia

Belgrade, 2006

The flux ratio of the [OIII] $\lambda\lambda$ 4959, 5007 Å lines in AGNs: measurements vs. theory

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Abstract.
Here we present the measurements of the flux ratio of the [OIII] $\lambda\lambda$ 4959, 5007 Å emission lines for the sample of 62 AGNs, obtained from SDSS Database and from the published observations. We selected the sample using the criteria of high signal to noise ratio and the same line shapes of 4959 and 5007 lines. We found that the flux ratio is 2.99±0.08, which is in a good agreement with the theoretical value of 2.98 given by Leisy and Zeippen (2000).

Keywords: AGN, NLR, line profiles, [OIII] lines, flux ratio
PACS: 95.30.Ky, 98.54.Cm, 95.75.Fg, 98.62.Ra

INTRODUCTION

The forbidden [OIII] $\lambda\lambda$ 4958.911, 5006.843 Å spectral emission lines are extremely bright in the spectra of photoionized nebulae and in the spectra of the Narrow Line Region (NLR) of AGNs. NLR is fotoionized gas region surrounding the accreting super massive black hole in the center of an AGN. In the diffuse conditions found in nebulae and NLRs, atoms and ions could survive a long time without undergoing collisions. This means that there is sufficient time for excited metastable states to decay, which explains forbidden line emissions. These lines could not be observed in the laboratory where it was not possible to produce collision-free conditions over that timeframe. This transition is strongly forbidden for electric dipoles by the Laporte rule, so the observed transitions are electric quadripole or magnetic dipole ones [1].

Since transitions are strongly forbidden and since both lines originate on the same energy level, both lines have exactly the same emission line profile. Their flux ratios depend only on atomic properties - the energy differences between the fine structure levels and Einstein A-coefficients. External physical condition as density, temperature and velocities, have no influence on flux ratios [2].

The aim of this paper is to measure the [OIII] 4959, 5007 flux ratio in an AGN sample and to compare the obtained results with theoretical ones and with results obtained up to now, only for planetary nebulae, demonstrating that and AGN spectra might be used for such purpose with the appropriate accuracy. The actual value of the lines flux ratio may be useful in spectral analysis of observational datasets.

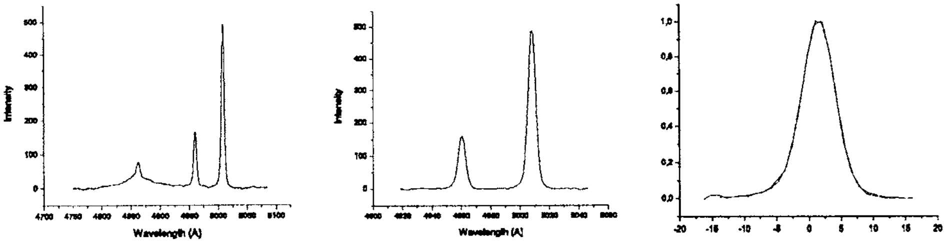

FIGURE 1. Example of the selected spectrum (SDSS J082308.29+42252000.00) with the same shapes of the [OIII] λλ 4959, 5007 Å lines.

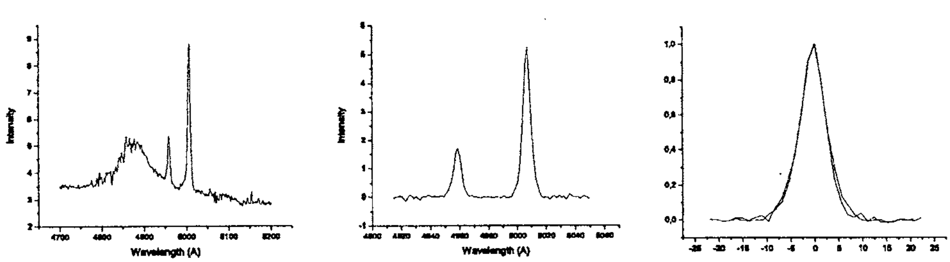

FIGURE 2. Example of the spectrum (PKS 2135-14) where the line shapes are slightly different.

THE LINE RATIO

Up to now, all direct flux ratio measurements of the [OIII] λλ 4959, 5007 Å lines have been made for planetary nebulae spectra. Also, these ratios were obtained in some papers as by-product, analyzing spectra of quasars or galaxies, or were used as a checking method.

The theoretical work of Galavis et al. [3] gives an [OIII] λλ 4959, 5007 Å flux ratio of 2.89. On the other hand, Storey and Zeippen [4] obtained theoretical value of 2.98, taking into account the higher order relativistic corrections for the magnetic dipole operator calculations.

Using planetary nebulae spectra, Rosa [5] measured a flux ratio of 3.03±0.03, while measurements of Iye et al. [6] give a value of 3.17±0.04, and that of Leisy and Dennefeld [7] 3.00±0.08.

Bahcall et al. [2], used spectra of quasars obtained from the Sloan Digital Sky Survey (SDSS) Early Data Release, to test the time dependence of the fine structure constant. As a by-product, they measured line flux ratio value of 2.99±0.02.

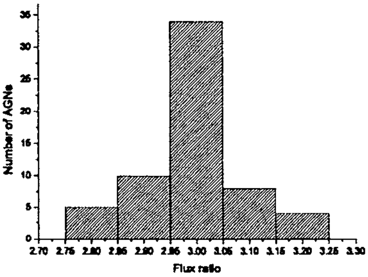

FIGURE 3. Histogram showing the distribution of the measured flux ratio of the initial 62 AGNs sample.

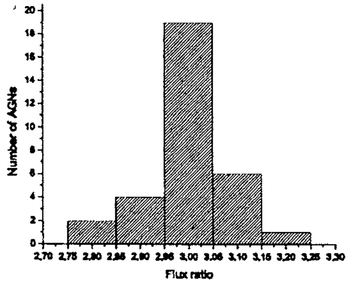

FIGURE 4. Histogram showing the distribution of the measured flux ratio of the final 32 AGNs sample.

THE SAMPLE AND MEASUREMENTS

We selected our AGN sample spectra, with high signal to noise ratio, from the latest Date Release Four (DR4) of the SDSS Database and from observations described in paper of Marziani et al. [8]. We subtracted the continuum by using DIPSO software, and in some spectra we subtracted the H_β and FeII emission lines which contaminate the [OIII] $\lambda\lambda$ 4959, 5007 Å lines.

After that we compared the [OIII] $\lambda\lambda$ 4959, 5007 Å line profiles (see Figs. 1 and 2) by DIPSO software and we selected our initial sample of 62 AGNs by using the criteria that the shapes of 5007 and 4959 lines are the same or different in a small percent.

From the initial sample of 62 AGNs, a number of 32 AGNs satisfy the criteria that the line profiles of both [OIII] lines are identical (Figure 1). The rest of spectra have slightly different line shapes (Figure 2). We measured the flux ratio for initial sample of 62 spectra and for final sample of 32 spectra. Here we present a histogram of the flux ratio values of the initial sample (Figure 3) and the final sample (Figure 4).

RESULTS AND CONCLUSIONS

For the initial sample of 62 objects we found flux ratio 2.99±0.10, and for the final sample of 32 AGNs a value of 2.99±0.08. The obtained flux ratios in both case are in reasonable agreement with the theoretical predictions by Storey and Zeippen (2000). We showed here that the spectra of AGNs could be also used for checks of such theoretical calculations.

ACKNOWLEDGMENTS

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and posters

Veto, B.
Konkoly Observatory, Budapest

Magnetic rotator model of HD 217833

The phenomen of the light-variation of the intermediate rotator (P = 5.39 days), He-weak Bp star HD 217833 is examined in the aspect, how a periodic variation of the UBV/RI/ light-curve could be explained by the rotation of a star whose atmosphere is magnetically destorted. Some estimations for the temperature inhomogenities and for the atmosphere distortion are presented from the suggested model.

Zverko, J., Zboril, M., Budaj, J.
Astronomical Institute, Slovak Academy of Sciences, Tatranska Lomnica

Relative photometry of λ5200 depression in CP stars

We present a relative photometry based on B, V and narrow band filter (centered to deep peak of the λ5200 depression) to obtain some informations about a narrow peak of well known λ5200 depression as well as some preliminary results indicating temperature dependence of the central peak of the depression.

Vince, I., Popovic, L., Dimitrijevic, M. S.
Astronomical Observatory, Belgrade

Stark broadening of heavy ion spectral lines in spectra of CP stars

A number of spectral lines of heavy ions has been observed in spectra of CP (O, B and A type) stars where Stark broadening is the main pressure broadening mechanism. In this paper we present calculated Stark width of two Zn II, two Br II and two Cd II spectral lines. Stark broadening data are calculated within modified semiempirical approach for electron density (Ne) of 10e15 cm^{-3}(Ne ≈ the density of the layers where heavy ion lines are formed in CP stars) and electron temperature of 12,000 K, and compared with corresponding Doppler and natural widths.

Vincze, I. J.
Gothard Astrophysical Observatory of Loránd Eötvös University

Statistical analysis of physical parameters of CP stars

The investigated sample contents 70 CP2 stars. The following parameters are studied: spectral type, chemical peculiarity, period of rotation, equatorial rotation velocity, magnetic extreme, magnetic obliquity, ratio of magnetic extreme, effective temperature and stellar radius.
Conclusions: Silicon is pointed out by Megessier (1984) to be overabundant everywhere on the surface of the stars younger than 5*10e7 or 10e8, with a large maximum of abundance in the equatorial belt. After 5*10e7 or 10e8 years no more equatorial maximum exists and silicon is less overabundant on the stellar surface. A slight Si overabundance remains only at the two polar caps for the oldest star. After this evolu-

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17 D

STARK BROADENING PARAMETERS OF SINGLY IONIZED IODINE LINES

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Stark broadening data are needed for a number of problems in astrophysical and laboratory plasma. Recently the report on the Stark broadening of several singly and doubly ionized iodine spectral line have been published in Ref. /1/. In order to compare experimental data with theoretical values we have calculated Stark broadening parameters of nine singly ionized iodine spectral lines by using the modified semiempirical aproach /2/. The atomic data needed for calculation have been taken from Ref. /3,4/.

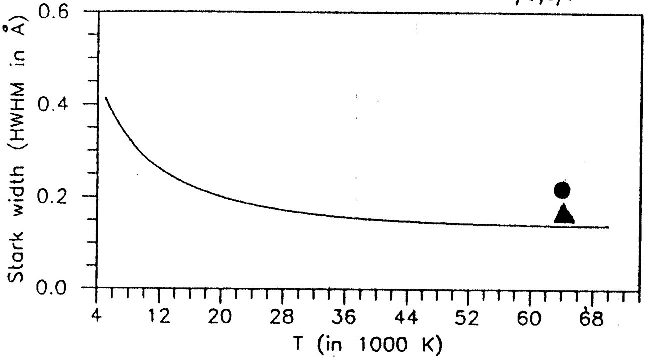

Fig. 1. *Stark width (HWHM) of* I^+, $6s^5S_2^0 - 6p^5P_3$ *transition: (—) - present calculations,* ▲ *- estimate by Labat et al. /1/ by using the method from Ref /5/,* ● *- experimental data /1/.*

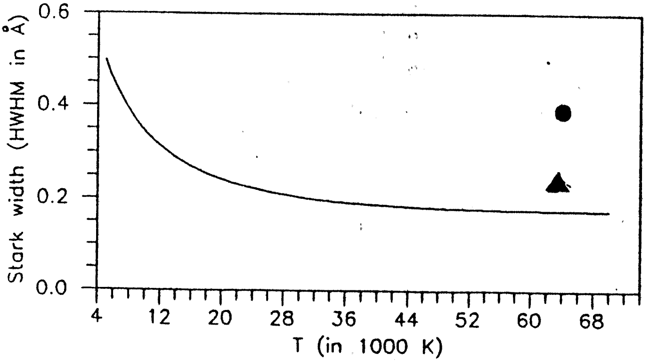

Fig. 2. *As in Fig. 1., but for* $6s^3S_1^0 - 6p^3P_2$ *transition.*

Stark half widths at half maximum intensity (HWHM) and shifts for an electron density of 10^{23} cm^{-3} and temperatures from 5,000 up to 70,000 for nine singly ionized spectral line are presented in Table 1. In Figs 1. and 2. our results have been compared with available experimental data /1/.

Table 1. *Stark width (HWHM) and shift as a function of temperature. The electron density of* 10^{23} m^{-3}.

TRANSITION	T (K)	WIDTH [Å]	SHIFT [Å]	TRANSITION	WIDTH [Å]	SHIFT [Å]
	5000.	.787E-02	.206E-02		.156E-01	.122E-01
	10000.	.543E-02	.161E-02		.108E-01	.901E-02
$5p^4\ {}^3P - 5d^3D^0$	20000.	.376E-02	.139E-02	$5p^4\ {}^3P - 6s^3S^0$	.760E-02	.695E-02
	30000.	.310E-02	.136E-02		.631E-02	.632E-02
$\lambda = 1117.80$ Å	40000.	.278E-02	.142E-02	$\lambda = 1222.94$ Å	.567E-02	.623E-02
	70000.	.253E-02	.186E-02		.488E-02	.626E-02
	5000.	.471	-.193		.250	-.669E-01
	10000.	.327	-.140		.177	-.511E-01
$6s^5S^0 - 6p^5P$	20000.	.228	-.104	$6s^5S^0 - 7p^5P$	.160	- .524E-01
	30000.	.191	898E-01		.140	-.451E-01
$\lambda = 5326.29$ Å	40000.	.174	-.855E-01	$\lambda = 2475.18$ Å	.130	-.411E-01
	70000.	.159	-.723E-01		.119	-.397E-01
	5000.	.770	-.413E-01		.305	-.464E-01
	10000.	.533	-.277E-01		.216	-.368E-01
$5d^5D^0 - 6p^5P$	20000.	.371	-.168E-01	$5d^5D^0 - 7p^5P$	.161	-.328E-01
	30000.	.309	-.117E-01		.141	-.265E-01
$\lambda = 7433.09$ Å	40000.	.280	-.840E-01	$\lambda = 2571.37$ Å	.131	-.223E-01
	70000.	.258	.133E-01		.119	-.211E-01
	5000.	1.34	.859		16.5	-7.96
	10000.	.950	.671		11.8	-6.28
$6p^5P - 7s^5S^0$	20000.	.726	.627	$7s^5S^0 - 7p^5P$	9.18	-5.90
	30000.	.655	.612		8.43	-5.61
$\lambda = 5319.15$ Å	40000.	.632	.559	$\lambda = 15068.28$ Å	8.19	-5.05
	70000.	.612	.365		7.98	-3.58

TRANSITION	T (K)	WIDTH [Å]	SHIFT [Å]	T (K)	WIDTH [Å]	SHIFT [Å]
	5000.	.562	-.286	30000.	.231	-.139
$6s^3S^0 - 6p^3P$	10000.	.389	-.208	40000.	.213	-.135
$\lambda = 5717.32$ Å	20000.	.274	-.156	70000.	.199	-.120

Taking into account the complexity of the ionized iodine spectrum, the accordance of theoretical results with experimental data is encouraging.

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17 D

ON THE STARK BROADENING OF Al I SPECTRAL LINES

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Stark broadening parameters of neutral aluminium lines are of interest for laboratory plasma diagnostic and they have been determined experimentaly, e.g. in Refs. /1-6/ and theoretically (e.g. /1,5,7/) several times.

By using the semiclassical-perturbation formalism /8,9/ we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 22 Al I multiplets. A summary of the formalism is given in Ref. 10. Here, we discuss the results for Al I, along with a

Table 1. *Comparison between the experimental Stark full widths of Al I lines (denoted by Wm - corresponding references are given in the last column) with different calculations. Semiclassical calculations: WDSB-present results; WBG - Ref. /7/ WCO - Calculations in Ref. /5/ by using the theory of Cooper and Oertel. The electron density N is equal to 10^{17} cm^{-3}.*

Transition	Lamda(A)	T(K)	N(10+17 cm-3)	Wm(A)	WDSB(A)	WBG(A)	WCO(A)	Ref.
3p-4s	3961.52	9670	1.42	0.63	0.39	0.44	0.34	1
		11000*	0.1*	0.038*	0.028	0.031		2
		11700	2.5	0.84	0.72	0.80		3,4
		13200	1.28	0.54	0.37	0.42		5
		13600	4.5	1.30	1.32	1.48		6
	3944.01	9670	1.42	0.46	0.39	0.44	0.34	1
		11000*	0.1*	0.037*	0.028	0.031		2
		11700	2.5	0.84	0.72	0.80		3,4
		13200	1.28	0.54	0.37	0.42		5
		13600	4.5	1.40	1.32	1.48		6
3p-3d	3082.15	11000*	0.1*	0.045*	0.043	0.52		2
		13200	1.28	0.51	0.55	0.66		5
	3092.71	11000*	0.1*	0.049*	0.043	0.52		2
		13200	1.28	0.51	0.55	0.66		5

*

Results taken in electron density range (0.15-0.60) 10+17 cm-3 and T range 10000-12000 K.

Table 2. *Same as in Table 1. but for the shift.*

Transition	Lamda(A)	T(K)	N(10+17 cm-3)	dm(A)	dDSB(A)	dBG(A)	dCO(A)	Ref.
3p-4s	3961.52	9670	1.42	0.14	0.32	0.26	0.23	1
		11700	2.5	0.42	0.57	0.48		3,4
		13200	1.28	0.31	0.30	0.25		5
		13600	4.5	0.86	1.05	0.88		6
	3944.01	9670	1.42	0.14	0.32	0.26	0.23	1
		11700	2.5	0.42	0.57	0.48		3,4
		13200	1.28	0.31	0.30	0.25		5
		13600	4.5	0.93	1.05	0.88		6
3p-3d	3082.15	13200	1.28	0.19	0.26	0.25		5
	3092.71	13200	1.28	0.19	0.26	0.25		5

comparison with experimental data /1-6/ and other theoretical results /5, 7/.

In Tables 1 and 2, the present results are compared with experimental data /1-6/, and with other semiclassical calculations /5,7/. In order to avoid different procedures for ion broadening contribution calculation within different theories, and to better compare different theoretical approaches, only theorertical electron impact broadening parameters are presented. We see that different theoretical approaches agree very well. If one takes into account that the ion broadening contribution, analysed in detail in Refs. 1 and 5, will increase Stark Broadening parameters for around 10 percents, the agreement with experimental data is also good. Particularly satisfactory is the mutual agreement in the case of shift, since the shift values are more complicated for reliable semiclassical calculations than the widths.

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STARK BROADENING OF F VII SPECTRAL LINES

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In order to continue our investigation of Stark broadening behavior along the lithium isoelectronic sequence /see e.g. 1/, we have calculated electron-, proton-, and He III- impact line widths and shifts for 20 F VII multiplets, by using the semiclassical-perturbation formalism /2,3/. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and He III - impacts have been calculated. A summary of the formalism is given in Ref. /4/. A summary of the formalism and the complete results will be published elsewhere /5/. Here, the obtained results will be discussed and compared with the available experimental data /6/ and other theoretical calculations (see Ref. /6/).

Table 1. *This table shows electron-, proton-, and He III- impact broadening parameters for F VII. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By using c [see Eq. (5) in Ref. /4/], we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.*

PERTURBER DENSITY = 0.1E+18 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		He III	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
FVII 2S-2P	100000.	0.893E-03	-0.165E-04	0.174E-05	-0.692E-05	0.324E-05	-0.138E-04
885.6 A	200000.	0.653E-03	-0.167E-04	0.557E-05	-0.137E-04	0.105E-04	-0.274E-04
C= 0.89E+20	500000.	0.428E-03	-0.186E-04	0.201E-04	-0.285E-04	0.389E-04	-0.575E-04
	1000000.	0.318E-03	-0.181E-04	0.368E-04	-0.411E-04	0.727E-04	-0.833E-04
FVII 2S-3P	100000.	0.562E-04	0.874E-06	0.114E-05	0.182E-05	0.218E-05	0.364E-05
113.0 A	200000.	0.418E-04	0.769E-06	0.254E-05	0.297E-05	0.498E-05	0.601E-05
C= 0.13E+18	500000.	0.292E-04	0.657E-06	0.480E-05	0.450E-05	0.958E-05	0.918E-05
	1000000.	0.227E-04	0.567E-06	0.620E-05	0.540E-05	0.125E-04	0.110E-04
FVII 2S-4P	100000.	0.967E-04	0.333E-05	0.678E-05	0.840E-05	0.136E-04	0.169E-04
86.7 A	200000.	0.744E-04	0.323E-05	0.113E-04	0.115E-04	0.227E-04	0.235E-04
C= 0.32E+17	500000.	0.541E-04	0.274E-05	0.157E-04	0.147E-04	0.322E-04	0.298E-04
	1000000.	0.432E-04	0.206E-05	0.202E-04	0.175E-04	0.402E-04	0.360E-04
FVII 2S-5P	100000.	0.189E-03	0.925E-05	0.243E-04	0.252E-04	0.487E-04	0.509E-04
78.4 A	200000.	0.149E-03	0.885E-05	0.321E-04	0.306E-04	0.656E-04	0.623E-04
C= 0.14E+17	500000.	0.111E-03	0.658E-05	0.432E-04	0.389E-04	0.861E-04	0.796E-04
	1000000.	0.895E-04	0.523E-05	0.511E-04	0.436E-04	0.108E-03	0.909E-04
FVII 3S-3P	100000.	0.629E-01	-0.821E-03	0.700E-03	0.134E-04	0.132E-02	0.266E-04
3257.4 A	200000.	0.472E-01	-0.132E-02	0.139E-02	0.268E-04	0.268E-02	0.537E-04
C= 0.11E+21	500000.	0.334E-01	-0.133E-02	0.239E-02	0.652E-04	0.468E-02	0.131E-03
	1000000.	0.264E-01	-0.133E-02	0.289E-02	0.113E-03	0.574E-02	0.227E-03
FVII 3S-4P	100000.	0.161E-02	0.334E-04	0.966E-04	0.117E-03	0.192E-03	0.236E-03
335.2 A	200000.	0.124E-02	0.275E-04	0.160E-03	0.161E-03	0.320E-03	0.328E-03
C= 0.48E+18	500000.	0.905E-03	0.211E-04	0.226E-03	0.205E-03	0.455E-03	0.416E-03
	1000000.	0.725E-03	0.117E-04	0.276E-03	0.246E-03	0.544E-03	0.498E-03

Table 2. *Comparison between F VII $3s^2S$-$3p^2P^o$ experimental Stark widths (FWHM) Wm - Glenzer et al. /6/, with calculated widths: WDSB - present results; WG - calculations in /6/ by using the symplified semiclassical approach (Eq. 526 in /7/); WDK - calculations in /6/ by using the modified semiempirical approach /9/; WHB - calculations in /6/ by using the method of Hey & Breger /8/. With N is denoted perturber density and with T Temperature.*

Ne(10+18 cm-3)	kT(eV)	Wm(A)	Wm/WDSB	Wm/WG	Wm/WDK	Wm/WHB
2.92	18.5	1.49	1.08	1.51	1.69	1.35
2.10	16.6	1.11	1.07	1.48	1.71	1.34
1.57	14.4	0.87	1.07	1.51	1.75	1.36

A sample of our results is shown in Table 1. Obtained results for $3s^2S$-$3p^2P^o$ multiplet have been compared in Table 2 with existing experimental data (Glenzer et al /6/) and with other calculations /6/ by using different approximate approaches /7,8,9/. We can see that exist the good agreement between experiment and semiclassical calculations as well as the reasonable agreement between different approximate approaches and more sophysticated semiclassical calculations. For F VII $3s^2S$-$3p^2P^o$ Stark width also exist a simple estimate /10/ based on regularities investigations. For electron density of 10^{17} cm^{-3} and temperature of 60000 K, they give full width of 0.070 Åwhile we obtain 0.079 Å, what is a very encouraging agreement.

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PROGRESS OF STARK-B DATABASE AND SERBIAN VIRTUAL OBSERVATORY

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Abstract. Progress of the work on development of STARK-B database for Stark broadening parameters of isolated non-hydrogenic lines and of Serbian Virtual Observatory – SerVO is presented. STARK-B database enters in the Virtual Atomic and Molecular Data Center – VAMDC.

1. INTRODUCTION

According to the idea formulated at the end of 2000, Virtual observatories are created to retrieve and analyze astronomical data obtained in various observatories and cosmic missions. At Belgrade Astronomical Observatory the work on Serbian Virtual Observatory [1-4] (http://www.servo.aob.rs/~darko) started at 2008, after long lasting interest for organization of our scientific results in databases.

As a first trace in documents we can cite de letter of one of the authors (MSD) to Mr Del Bigio in UNESCO in Paris, of 4. 11. 1992, asking to obtain CDS/ISIS software for creation of a database and the corresponding Agreement signed the same day in UNESCO Headquarters in Paris by MSD and Giampaolo Del Bigio, Programme Manager, Division of the General Information Programme of UNESCO. After, at the end of nineties, we created database BELDATA [5-10] containing Stark broadening parameters, which, after the changement of management at Observatory in 2002, was transferred in Paris, where was further developed and named STARK-B [11]. This database enters also in Virtual Atomic and Molecular Data Center (VAMDC – [12-15]), an FP7 founded project. Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela.

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka

Kovačević, Darko Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

In this contribution we discuss the project of Serbian Virtual Observatory (SerVO), and STARK-B database, their actual state and recent developments.

2. STARK-B DATABASE

The database STARK-B is available on line at the web address http://stark-b.obspm.fr/ and is further developing by Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon (Sylvie Sahal-Bréchot and Nicolas Moreau) and the Astronomical Observatory of Belgrade (Milan S. Dimitrijević). This database contains Stark line broadening parameters (widths and shifts) for isolated lines, obtained within the impact approximation using the semiclassical perturbation approach. STARK-B is currently developed in Paris, and a mirror site is under construction in Belgrade. STARK-B is one of databases of the european FP7 project: Virtual Atomic and Molecular Data Center – VAMDC.

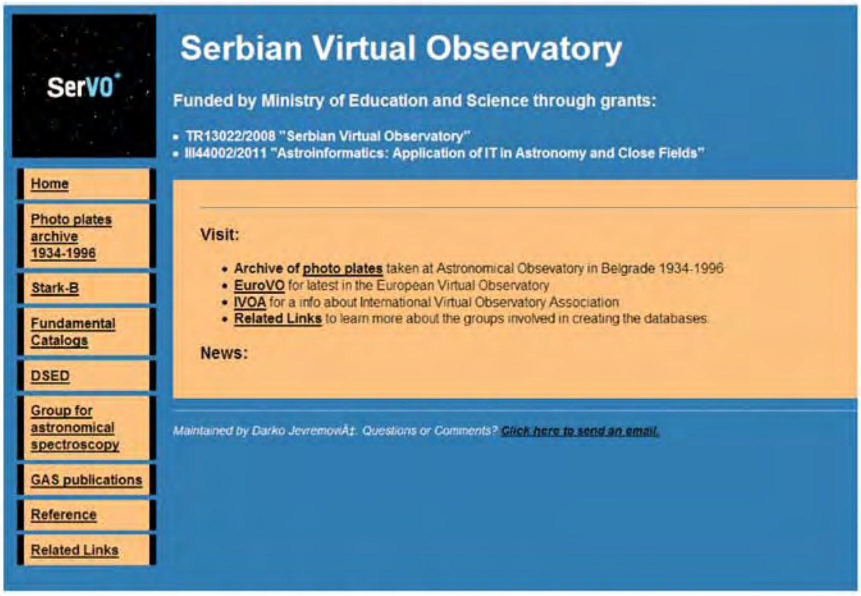
Choose an element and an ionization degree

H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

Figure 1. "Access to data" page of STARK-B.

3. SERBIAN VIRTUAL OBSERVATORY - SerVO

SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) was founded as the project TR13022 financed by the Ministry of Science and Technological Development of Republic of Serbia from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". Main objectives are to publish data obtained by Serbian astronomers as well as to provide astronomers in Serbia with VO tools for their research.



Serbian Virtual Observatory

Funded by Ministry of Education and Science through grants:

- TR13022/2008 "Serbian Virtual Observatory"
- III44002/2011 "Astroinformatics: Application of IT in Astronomy and Close Fields"

Visit:

- Archive of photo plates taken at Astronomical Obsevatory in Belgrade 1934-1996
- EuroVO for latest in the European Virtual Observatory
- IVOA for a info about International Virtual Observatory Association
- Related Links to learn more about the groups involved in creating the databases

News:

Maintained by Darko JevremoviÄ‡. Questions or Comments? Click here to send an email.

Figure 2. Homepage of Serbian Virtual Observatory.

Now, SerVO has five different collections:

1. Archive of photo-plates from the 1934-1996 period.
2. Link to, and the mirror site in construction of the STARK-B database.
3. Fundamental Catalogues
4. Link to, and the mirror site in construction of the DSED (Dartmouth Stellar Evolution Database) database.
5. Electronic editions of the GAS – Group for Astrophysical Spectroscopy.

Work on SerVO is in progress and we hope to enter soon in IVOA. We plan also to further develop and improve STARK-B database, and to enlarge and complete all mentioned collections of SerVO. We also plan to develop further the Serbian VAMDC node with an aim to become a regional center in South Eastern Europe

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Progress Report

THE STRUCTURE OF Si IV REGION IN Be STARS; A STUDY OF Si IV SPECTRAL LINES IN 68 Be STARS

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Abstract. In this paper, using the GR model, we analyze the UV Si IV resonance lines in the spectra of 68 Be stars of different spectral subtypes, in order to detect the structure of Si IV region. We study the presence and behavior of absorption components and analyze their characteristics. From this analysis we can calculate the values of a group of physical parameters, such as the apparent rotational and radial velocities, the random velocities of the thermal motions of the ions, the Full Width at Half Maximum (FWHM), the optical depth, as well as the absorbed energy and the column density of the independent regions of matter which produce the main and the satellites components of the studied spectral lines. Finally, we present the relations between these physical parameters and the spectral subtypes of the studied stars and we give our results about the structure of the Si IV region in their atmosphere.

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THE NON-SYMMETRIC ION-ATOM ABSORPTION PROCESSES IN THE STELAR ATMOSPHERES

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Abstract. The aim of this work is to draw attention to the processes of absorption charge-exchange and photo-association in non-symmetric ion-atom collisions together with the processes of the photo-dissociation as a factor of influence on the opacity of solar and some DB white dwarfs atmospheres in UV and VUV region. In all considered cases the absorption processes with $A = He$ and $B = H$ are taken into account. In the case of the solar atmosphere the absorption processes with $A = H$ and $B = Mg$, Si and Al are also included in the considerations. On chosen examples it has been established that the examined processes generate rather wide molecular absorption bands in the UV and VUV region, which should be taken into account for the interpretation of data obtained from laboratory measurements or astrophysical observations.

1.INTRODUCTION

In a series of previous papers the influence of the processes of radiative charge exchange in symmetric $H(1s) + H^+$ and $He(1s^2) + He^+(1s)$ collisions and corresponding photo-association/dissociation processes on the opacity of stelar atmospheres was studied. It was shown that in the hydrogen case these processes are important for the atmospheres of the Sun and of some DA white dwarfs [1], and in the helium case - for the atmospheres of some DB and DA white dwarfs [1, 2]. The mentioned papers made it clear that at least symmetric ion-atom radiative collisions play a significant role in the stellar atmospheres. But the question, whether some non-symmetric ion-atom radiative processes can also influence the optical characteristics of the considered stellar atmospheres, is still open. A detailed study of such non-symmetric processes in connection with the stellar atmospheres would require a very extensive research, and it remains a task for the future. The aim of this article is to point out at least some objects where such processes could be of interest, and to show the possible ways of describing their influence. For this purpose it was natural to start from the same DB white dwarfs and the solar atmosphere (which were considered in previous papers, since adequate models exist for them). In the case of DB white dwarfs we mean models presented in [3], as well as in [4]. The necessary

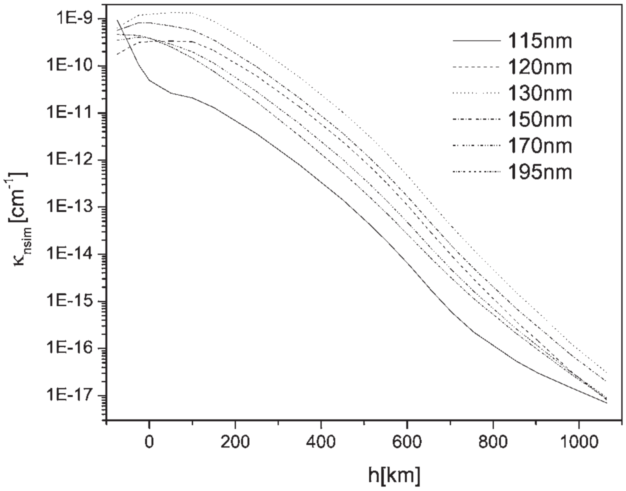

Figure 1. Quiet Sun. Spectral absorption coefficient $\kappa_{nsim}(\lambda, T)$, for 115 nm$\leq \lambda \leq$ 195 nm.

models of the solar atmosphere were described in [5, 6]. A composition of the mentioned models and the previous results for the ion-atom symmetric radiative process suggest that, in the considered atmospheres the following non-symmetric absorption processes have to be taken into account

$$\varepsilon_\lambda + AB^+ \longrightarrow A^+ + B, \tag{1}$$

$$\varepsilon_\lambda + A + B^+ \longrightarrow A^+ + B, \tag{2}$$

$$\varepsilon_\lambda + A + B^+ \longrightarrow (AB^+)^*, \tag{3}$$

where B is the ground state atom with the ionization potential I_B which is less than the ionization potential I_A of the atom A, AB^+ - the corresponding molecular ion. In the general case, apart from these absorption processes, the corresponding inverse emission processes should also be considered. However, it can be shown that, under the conditions of plasma taken from the models mentioned above, the significance of such emission processes can be neglected in comparison with other relevant emission processes. In accordance with models, in the both cases (Sun and DB white dwarfs) is possible that $A = He(1s^2)$ and $B = H(1s)$, and in the case of the Sun, it is additionally possible that $A = H(1s)$, and that B is the atom of a

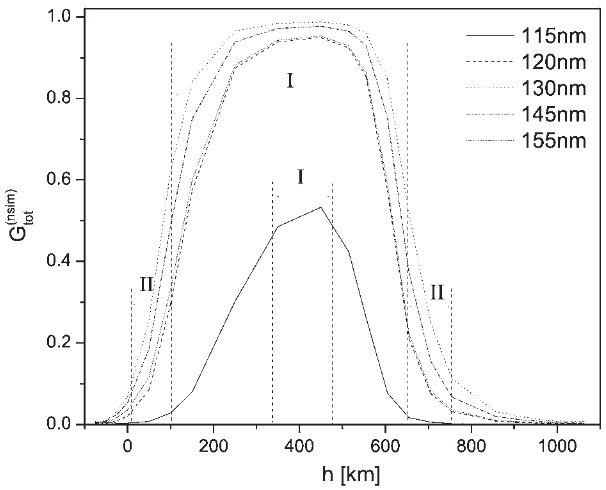

Figure 2. The behavior of the quantity $G_{tot}^{(nsim)}(\lambda)$ as the function of h for the Solar atmosphere for 115nm $\leq \lambda \leq$ 155nm.

metal. The contribution of the considered non-symmetric ion-atom absorption processes is described here by the spectral absorption coefficients in the UV and VUV region as the function of the local temperature T, wavelength λ, and the particle densities.

2.RESULTS AND DISCUSSION

The contribution of the considered non-symmetric ion-atom absorption processes (1)-(3) to the opacity of the solar atmosphere is described here by the spectral absorption coefficient $\kappa_{nsim}(\lambda, T)$. The behavior of $\kappa_{nsim}(\lambda, T)$ for several values of λ is illustrated by Fig.1, where h is the distance of considered layer from the referent one (h=0) in accordance with [5]. The calculated values of the quantity $G_{tot}^{(nsim)}(\lambda) = \kappa_{ia;nsim}(\lambda; T)/\kappa_{ia;tot}(\lambda; T)$, where $\kappa_{ia;tot}(\lambda; T)$ characterize the total contribution of all ion-atom absorption processes, i.e. symmetric and non-symmetric (1)-(3), is shown in Fig.2. From this figure one can see that around the temperature minimum ($T \lesssim$5000 K, 150 km$\lesssim h \lesssim$705 km) the contribution of non-symmetric processes are dominant in respect to the symmetric processes. Such region of the non-symmetric processes domination is denoted in these figures as the region "I". In the case of the DB white dwarfs atmospheres the results of the calculations of the spectral absorption coefficients $\kappa_{ia;nsim}(\lambda)$, as function of Rosseland optical depth τ for $-5.6 \leq$

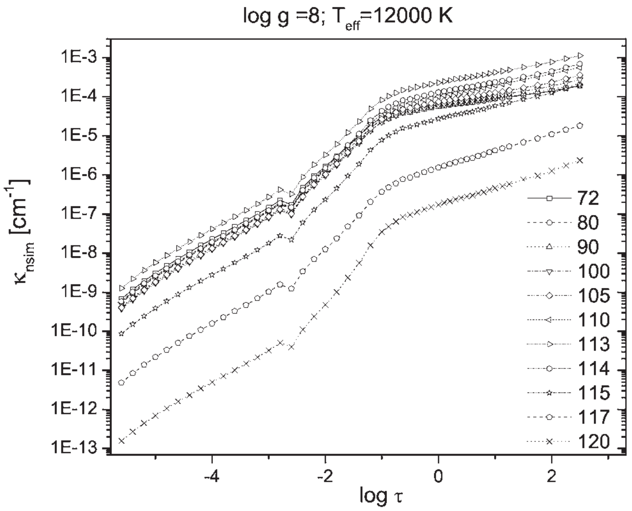

Figure 3. The spectral absorption coefficients, as function of Rosseland optical depth τ for the DB white dwarf atmosphere model with $log\ g = 8$ and $T_{eff} = 12000$ K.

log $\tau \leq 2.6$, are presented in Fig. 3 which relate to the model with log $g = 8$ and $T_{eff} = 12000$ K. The quantity $G^{(tot)}_{sim}(\lambda) = \kappa_{ia;tot}(\lambda)/\kappa_{ia;sim}(\lambda)$, where $\kappa_{ia;tot}(\lambda; T)$ characterize the total contribution of all ion-atom absorption processes, i.e. symmetric and non-symmetric (1) - (3), is shown in Fig. 4. Our results presented in [7] and here shows that the neglecting of the contribution of the non-symmetric processes to the opacity of the stellar atmospheres, in respect to the contribution of symmetric processes would caused noticeable errors. All mentioned facts suggest that the considered non-symmetric ion-atom absorption processes should be *ab initio* included in the stellar atmospheres models.

From the presented material it follows that the considered non-symmetric ion-atom absorption processes can not be treated only as one of the channel among many equal channels of the influence on the opacity of the stellar atmospheres. Namely, in the case of the solar atmosphere these nonsymmetric processes so increase the absorption of EM radiation around the temperature minimum, that this absorption caused by all (symmetric and non-symmetric) ion-atom absorption processes becomes almost uniform in the whole solar photosphere. Moreover, the presented results show that further investigations of these processes promise to demonstrate that they are so important as the known process of the photo-detachment of ion H-, which was treated until recently as the absolutely dominant.

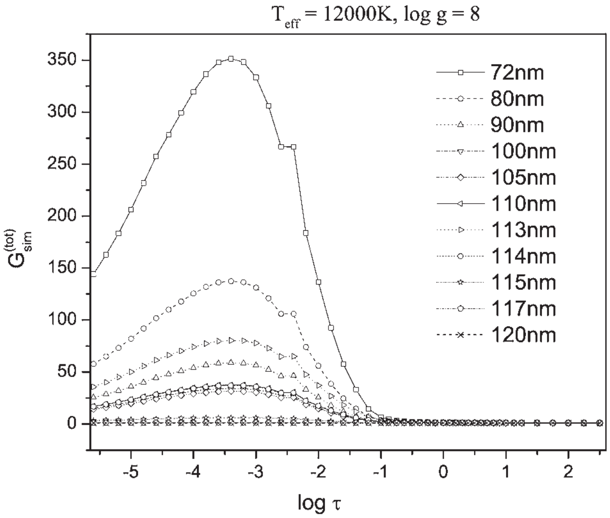

Figure 4. The quantity $G^{(tot)}_{sim}$, for the DB white dwarf atmosphere model with $log\ g = 8$ and $T_{eff} = 12000$ K.

Acknowlendgements

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2$^{\underline{eme}}$ COLLOQUE SUR

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P8

QUANTUM AND SEMICLASSICAL STARK WIDTH CALCULATION FOR THE LiI RESONANCE LINE

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In spite of the existence of very successful semiclassical calculations |1-4| for electron collisional broadening parameters, a sophisticated quantum mechanical calculation is interesting to perform. Our purpose is in fact to provide a quantitative check of the semiclassical perturbational treatment for the case of a neutral atom. Short range and exchange effects are more important for neutrals and this will make easier the discussion concerning some important aspects of the semiclassical treatment (cut off and strong collision terms). We have chosen the resonance line of LiI ($2s^2S$-$2p^2P$) because the polarisability of Li is very large both in the fundamental and excited states and therefore the importance of the polarisation potential will be easier to discuss.

Thus we have computed the impact Stark width of the LiI ($2s^2S$-$2p^2P$) resonance line, both quantum mechanically and semiclassically. According to Barnes and Peach |5| half halfwidth can be given as a sum of the contributions W_ℓ^{CC} of the various values of the perturber angular momenta ℓ, W_ℓ^{CC} being evaluated in terms of the scattering matrix elements. The connection with the semiclassical theory can be made by replacing the summation over ℓ by an integration over the impact parameter ρ of the perturbing classical particle. In order to exhibit the contribution to the line width of a given ℓ, we have defined the equivalent semiclassical Stark broadening parameter W_ℓ^{SC} in the following manner:

$$W_\ell^{SC} = N_e \int v f(v) dv \int_{\rho=\ell/k}^{\rho=(\ell+1)/k} 2\pi\rho d\rho \quad \mathrm{Re}\left[1-S_{ii}(\rho,v)S_{ff}^{-1}(\rho,v)\right]_{Av} \qquad (1)$$

This procedure will allow to check the validity of the semiclassical approximation by comparing step by step W_ℓ^{SC} with W_ℓ^{CC}.

For the quantum calculations, we used data from Burke and Taylor |6| when available. The close coupling solutions of Burke and Taylor have been obtained using a two state approximation, in which the levels 2s and 2p of Li have been explicitely included. We have calculated the lacking data in the same approximation, using Li wave functions from Weiss |7| and the code of Seaton and Wilson |8|. Those results are compared also with our semiclassical calculations.

We have also evaluated the contribution W_ℓ of the various angular momenta ℓ in the semiclassical halfwidth W of the LiI $2s^2S$-$2p^2P$, 6707.8Å line as given by eq. (1). Results for T = 2500, 5000, 10000 and 20000 K are given in fig. 1. One can see that the importance of higher ℓ-values increases with temperature and that perturbing electrons with ℓ=1, are the most important for the line width at T = 20000 K. For higher temperatures electrons with ℓ=2 are more effective. This is in accordance with the conclusion of Bely et al |9| that for neutrals typical ℓ-values of impact electrons are between 1 and 5.

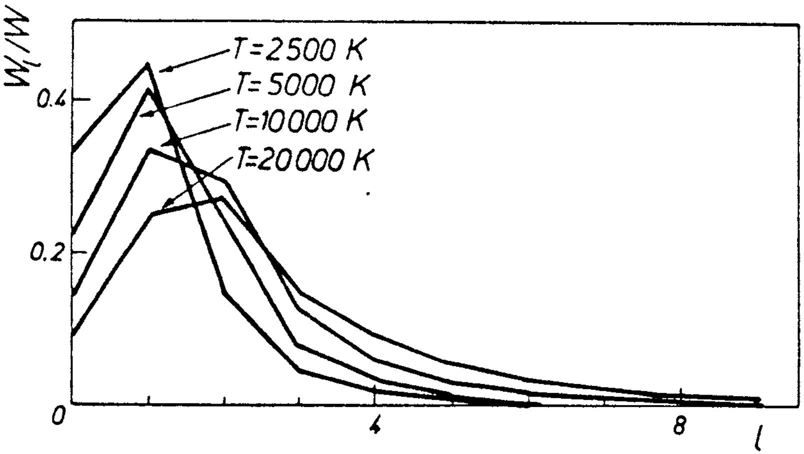

Fig. 1. Relative contributions W_ℓ/W of the various angular momenta ℓ of the colliding electron for the semiclassical halfwidth at different temperature.

In fig. 2, 2s-2p close coupling quantum width calculations (curve A) are presented; 2s-2p semiclassical results are shown on curve B and semiclassical results with all higher perturbing levels are shown on curve C, in order to exhibit the importance of the polarization of the $2p^2P$ term (since inelastic collisions are negligible at this low temperature). The polarization effects only the low ℓ values and the difference between quantum mechanical and semi classical calculations is most prominent for lowest ℓ values, while with the increase of ℓ the results converge as expected. The difference between quantum and semiclassical result for low ℓ values is due to the important contribution of the quantum resonance in the 2s-2s cross section |6| whereas the polarization effect modifies the quantum results by less than 10%.

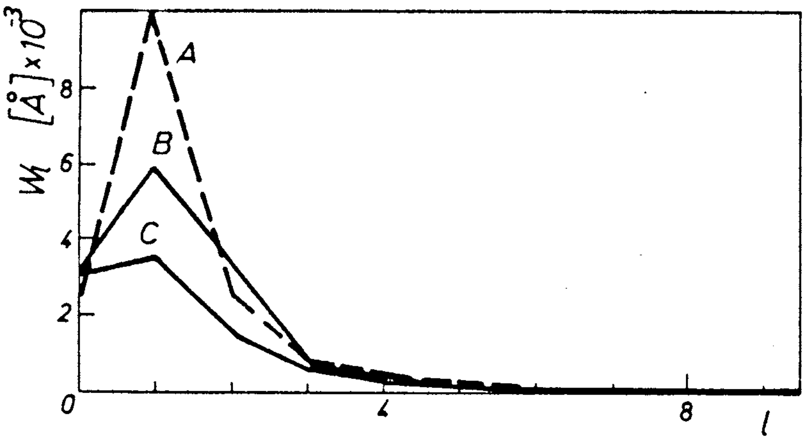

Fig. 2. Comparison between quantum mechanical (broken line) and semiclassical (full line) half halfwidth calculation for different ℓ values. Electron temperature is 5000 K and electron concentration 10^{16} cm^{-3}.

We have then investigated the influence of the cut off on the semiclassical calculations (fig. 3). At the chosen test temperature of 5000 K, the contribution of the inelastic collisions is quite weak and therefore a change of the corresponding cut off is negligible on the total halfwidth. On the other hand, a change of the cut off for the elastic collision contribution is important but only for ℓ = 0,1. This is an interesting result because we have chosen a rather low temperature and a neutral atom in order to increase short range and quantum close coupling effects and in spite of that, our results show that the semiclassical perturbational treatment is valid for smaller ℓ values than threoretically expected. Above analysis explains the feature and the variations reported on table 1. Firstly, one can recall that the MMM (model microfield method) calculation |10| is in the particular case of lithium equivalent to a close coupling dipolar semiclassical treatment because non-impact effects are negligible. The Bennet and Griem's |3| results should be equivalent to our perturbational semiclassical treatment: the main difference come from the choice of the cut offs and symmetrization procedure. The importance of the short range polarization effects for the widths is exhibited by comparing lines 2 and 3. In our case of the lithium resonance line, owing to the polarization effect, the width decrease.

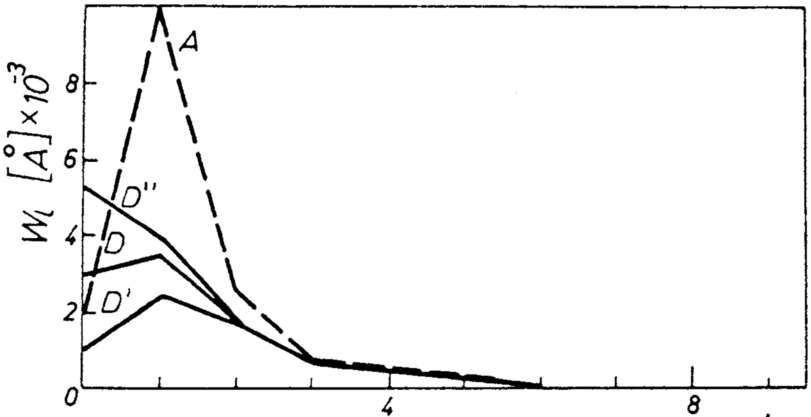

Fig. 3. Influence of the change of the cut off on the width l curves. D, D' and D" are obtained for cut offs R_2, R_2', R_2'' such that the corresponding phase shift $\delta(R_2') = 1/2\ \delta(R_2)$ and $\delta(R_2'') = 2\delta(R_2)$.

Table 1. LiI $2s^2S-2p^2P$, λ=6707.8Å: Half halfwidth in Å for $N_e = 10^{16} cm^{-3}$ as a function of the temperature; (1) close coupling; (2) semiclassical 2s-2p; (3) semiclassical including all the levels; (4) Benett and Griem |3|; (5) M.M.M. with 2s-2p levels; (6) M.M.M. with all levels included

T(K)	2500	5000	10000	20000
(1)	0.022	0.017	0.014	0.015
(2)	0.015	0.016	0.018	0.020
(3)	0.010	0.011	0.012	0.016
(4)	-	0.0099	0.014	0.020
(5)	0.012	0.014	0.016	-
(6)	0.0087	0.012	0.015	0.021

Concerning the variation of the width with the temperature we can see that the behaviour of the halfwidth is qualitatively different in quantum mechanical and semiclassical cases. In all semiclassical calculations, the halfwidth increases with temperature, whereas the quantum mechanical results are a decreasing function of temperature. This difference is connected with the behaviour of the quantum elastic 2s-2p cross section which give the predominant contribution to the width at low temperatures. Indeed, Burke and Taylor |11| have shown that the cross section peaks within 0.1 eV of 2s threshold due to the presence of low energy resonances in the second p waves.

As can be seen from table 2, the contribution $W_\ell \leq 1$ of these two waves is predominant at low energies, $W_\ell \leq 1$ is a decreasing and $W_\ell > 1$ an increasing function of temperature. It is evident that W is a decreasing function for lower and increasing for higher temperatures with turning point between 10000K and 20000K. Semiclassical calculations cannot take resonances into account, therefore the elastic cross section does not peak at low energy and the width increases with temperature for all temperatures.

Table 2. Comparison between quantum mechanical half halfwidths for $\ell = 0$ and $\ell = 1$, $W_{\ell\leq 1}$(Å) and $\ell > 1$, $W_{\ell>1}$(Å). $N_e = 10^{16}$ cm-3.

T(K)	2500	5000	10000	20000
$W_{\ell\leq 1}$(Å)	0.01695	0.01183	0.00803	0.00471
$W_{\ell>1}$(Å)	0.00475	0.00507	0.00637	0.00953

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We are indebted to J. Dubau, H. Van Regemorter, G. Nollez, A. Mazure and C. Goldbach for helpful discussions. Also one of us (M.S.D.) would like to acknowledge the financial support of RZN of Serbia and of the Observatoire de Meudon.

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ELECTRON IMPACT BROADENING OF MULTIPLY CHARGED ION LINES

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1. INTRODUCTION

For evaluation of Stark linewidths and shifts of non-hydrogenic spectral lines of ionized atoms, various theoretical approaches have been used (see e.g. Ref. 1). Most of these approaches require a considerable labour even for the evaluation of a single linewidth. Whenever a large number of theoretical data of the linewidths are required tedious calculations can be avoided if one uses simple, approximative formulae with good average accuracy.

Here, we develop two methods suitables for electron impact broadening estimates for isolated lines of ions of Be-isoelectronic sequence and alkali like ions, both based on our version |2| of the semiempirical method |3|.

2. MODIFIED SEMIEMPIRICAL METHOD

In 1968 Griem |3| suggested simple method for evaluation of electron impact broadening of ionic lines, based on semiempirical effective Gaunt factor approximation as proposed by Seaton |4| and Van Regemorter |5|. For singly ionized atoms, semiempirical formula agrees in average within 50% with experiment |1|. For multiply ionized atoms the agreement becomes worse and we made an attempt to extend the applicability of this approach to higher ionization stages |3|. To achieve this we have separated transitions to the perturbing levels in three groops: a) $\Delta n = 0$, $\ell \rightarrow \ell + 1$, b) $\Delta n = 0$, $\ell \rightarrow \ell - 1$ and c) $\Delta n \neq 0$ and, within each group, matrix elements are treated lumped together. For the values. Recently obtained data for the electron impact excitation collision strengths for $ns^2\ ^1S-nsnp\ ^1P^o$ resonance transitions in the Be isoelectronic sequence |8|, may be easily incorporated in modified semiempirical method. These data were obtained in the distorted wave approximation with consideration of exchange effects and approximate treatment of intrashell correlation effects in the target state |8|. Using relation between Gaunt factor and collision (Ω) and line (S) strength |8|

$$g = \frac{3\sqrt{3}}{8\pi}\ \frac{\Omega}{S}\ , \tag{4}$$

we included distorted wave results |8| obtained for highly ionized atoms in equation 1.

As an example we have calculated electron impact width of $2s^2\ ^2S-2p\ ^2P^o$, λ = 222.9 Å Ar XV line at $T_e = 4\times10^6$K and $N_e = 10^{22}$ cm^{-3}. Modified semiempirical approach, eq. 2, gives full half width w = 0.0574 Å while with distorted wave Gaunt factors incorporated the result is 0.0353 Å.

4. ELECTRON IMPACT BROADENING OF ALKALI LIKE IONS

Recently, Younger and Wiese |9| gave an analytical expression for the effective Gaunt factor for $\Delta n = 0$ transitions of alkali like ions. We can include this result for $\Delta n = 0$ in the method presented in section 1 by calculating g in the following manner:

$$\tilde{g} = (1 - \frac{1}{Z_e})(0.7 + \frac{1}{n})\ [0.6 + 0.25\ \ell n(\frac{E}{\Delta E_{ij}})] \tag{5}$$

Here Z_e is the effective charge of the ion. This formula is developed on the basis of the data for highly charged ions and we hope that this can extend applicability of relation 2 toward higher ionization stages.

As an numerical example we calculated electron impact width for $4p\ ^2P^o-4d\ ^2D$ (mult. 2) of SiIV at T = 25600 K and $N_e = 1 \times 10^{17}$ cm^{-3}.

Modified semiempirical method, eq. 2, gives w = 0.26 Å while with effective Gaunt factor from eq. 5; w = 0.32 Å. Both values are in good agreement with experimental value of Platiša et al |10|, w = 0.24.

transitions with $\Delta n = 0$, Kobzev |6| suggested for Gaunt factor an empirical value of $g = 0.9 - 1/Z$, at the threshold and we have adopted this suggestion. For transitions with $\Delta n \neq 0$, $g = 0.2$ at threshold is retained and the energy separation to the nearest perturbing level $E_{n,n+1}$ is taken as:

$$\Delta E_{n,n+1} = \frac{2Z^2 E_H}{n^{*3}} \tag{1}$$

Here, n^* is the effective principal quantum number while $(Z - 1)$ is the ionic charge. The electron impact line width (FWHM) can be calculated |3| from the following expression:

$$w = N \frac{8\pi}{3} \frac{\hbar^2}{m^2} \left(\frac{2m}{\pi kT}\right)^{1/2} \frac{\pi}{\sqrt{3}} \sum_{j,j'=i,f,i',f'} \left[\vec{R}^2_{\ell_j,\ell_j+1}\, \tilde{g}\left(\frac{E}{\Delta E_{\ell_j,\ell_j+1}}\right) + \right.$$

$$\left. + \vec{R}^2_{\ell_j,\ell_j-1}\, \tilde{g}\left(\frac{E}{\Delta E_{\ell_j,\ell_j-1}}\right) + \sum_{j'} (\vec{R}^2_{jj'})_{\Delta n \neq 0}\, \tilde{g}\left(\frac{3kTn_j^{*3}}{4Z^2 E_H}\right) \right] \tag{2}$$

$$\tilde{g}(x) = 0.7 - 1.1/Z + g(x)$$

Here $\vec{R}^2_{jj'}$ is the square of the coordinate operator matrix element |1| and i and f designate initial and final energy levels.

At high temperature limit, say $3kT/2\Delta E > 50$, all needed Gaunt factors may be calculated in accordance with the GBKO high temperature limit |7| viz:

$$\tilde{g}(T) = g(T) = \frac{\sqrt{3}}{\pi} \left[\frac{1}{2} + \ln \left(\frac{n^* kT}{ZE_H}\right) \right] \tag{3}$$

Comparison with experiments for doubly and triply ionized atoms yield, as an average ratio of measured to calculated widths, 1.06 ± 0.31 and 0.91 ± 0.41 respectively |3|.

3. ELECTRON IMPACT BROADENING IN Be ISOELECTRONIC SEQUENCE

Main limitation for the application of the semiempirical formula for highly ionized atoms imposes the lack of the effective Gaunt factor

5. CONCLUSION

The agreement between simple modified semiempirical approach and more sophisticated calculations is very encouraging and it indicates that this simple method can be used for estimation of electron impact contribution to the line width of multiply ionized atoms.

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The influence of non-elastic processes in $H^*(n) + H$ collisions to the Rydberg states population of hydrogen atom in laboratory and astrophysical plasmas

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The influence of two groups of non-elastic processes in $H^*(n) + H(1s)$ collisions to the Rydberg states populations of hydrogen atoms in weakly ionized plasmas was investigated here. The first group consists of the chemi-ionization and chemi-recombination processes

$$H(1s) + H^*(n) \leftrightarrow \vec{e} + \begin{cases} H^+ + H(1s), \\ H_2^+, \end{cases} \tag{1}$$

and the second group - the excitation and de-excitation processes

$$H^*(n) + H(1s) \leftrightarrow \begin{cases} H^*(n' = n + p) + H(1s), \\ H(1s) + H^*(n' = n + p), \end{cases} , \tag{2}$$

where $\vec{e}$ and H_2^+ denote the free electron and the hydrogen molecular ion in the ground electronic state, the principal quantum number $n \geq 4$ and $p \geq 1$. The rate coefficients of these processes were determined, on the base of already developed semi-classical method [1], for weakly ionized laboratory and astrophysical hydrogen plasmas (ionization degree less then 10^{-3}). With help of these rate coefficients the efficiency of the mentioned processes was compared with the efficiency of the other relevant ionization/recombination and excitation/de-excitation processes. It was shown that the exchange between the excited state atom populations within the lower part of the Rydberg region of n is determined by the processes (2) while the exchange between the mentioned group of Rydberg states as a wholeness and the continuum is determined by the chemi-ionization/recombination processes (1). It is important that all mentioned is related to the plasma of the part of Sun's photosphere and lower chromosphere (the region with $T < 6000K$) [2].

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On the influence of collisions with charged particles on Cr I lines in stellar atmospheres

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Using the semiclassical perturbation method, electron-, proton-, and ionized helium-impact line widths and shifts for the nine Crɪ spectral lines from the $4p^7P^0 - 4d^7D$ multiplet, have been calculated for a perturbed density of 10^{14} cm^{-3} and temperatures T = 2,500 − 50,000 K. The obtained results have been used to investigate the influence of Stark broadening effect in the Cr-rich Ap star β CrB atmosphere on line shapes of these lines.

From our investigation we can conclude:

(i) The calculated value of Stark widths as well as of shifts can be quiet different for the different lines, although these belong to the same multiplet.

(ii) The contribution of the proton and HeII collisions to the line width and shift is significant, and it is comparable and sometimes (depending of the electron temperature) even larger than electron-impact contribution.

(iii) Depending on the electron-, proton-, and HeII density in stellar atmosphere the Stark shift may contribute to the blue as well as to the red asymmetry of the same line.

(iv) To fit well Cr ɪ line wings we need to decrease the calculated Stark widths by 60-70%, which is the same order of overestimation as for Si ɪ lines [1]. The approximation formula of Cowley [2], used in the cases where the adequate semiclassical calculation is not possible due to the lack of reliable atomic data, predicts also overestimated influence of Stark broadening in comparison with observations.

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On the electron-impact broadening of the nitrogen (^{1}D)3s^{2}D - (^{1}D)3p^{2}P^o 7904.5 *Å* line

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Recently Bartecka et al. [1] have determined experimentally Stark widths (line widths due to collisions with charged particles) for N I 3s'^{2}D-3p'^{2}P^o multiplet and have found very large values. Obtained widths are 1.4 to 2.9 Å for electron densities (1.2-2.1) x 10^{16}cm^{-3} and temperatures 9200-13600 K. With the standard semiclassical theory [2] we obtain one order of magnitude smaller values.

Table 4: This table shows electron−impact broadening parameters (full width at half intensity maximum W, shift d, the quasistatic ion broadening parameter A, the total width due to elecron- and ion-impacts W$_{e+i}$(Å), and the coefficient of the ion-dynamic contribution D for N I 3s'^{2}D-3p'^{2}P^o multiplet, for perturber density of 10^{16}cm^{-3} and temperatures from 2500 up to 50,000 K. Transition and averaged wavelength for the multiplet (in Å) are also given in the Table. By dividing C by the corresponding full width at half maximum, we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	A	W$_{e+i}$(Å)	D
3s'^{2}D-3p'^{2}P^o	2500.	0.682E-01	0.359E-01	0.1345E-02	0.6822E-01	0.3600E-01
	5000.	0.736E-01	0.462E-01	0.1269E-02	0.7371E-01	0.4628E-01
7906.7 A	10000.	0.845E-01	0.430E-01	0.1145E-02	0.8457E-01	0.4312E-01
C = 0.43E+20	20000.	0.108	0.400E-01	0.9531E-03	0.1080	0.4013E-01
	30000.	0.127	0.334E-01	0.8427E-03	0.1273	0.3358E-01
	50000.	0.156	0.270E-01	0.7218E-03	0.1564	0.2716E-01

All details on the theory and calculation procedure are given in [2,3]. Needed atomic energy levels are taken from [4]. Here are provided all data for Stark broadening, needed for discussion and different considerations. Further experimental and theoretical investigations of this interesting multiplet are needed.

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Research in Astrophysics from Space (E)
Seyfert Galaxies: Known and the Unknown (E1.6)

IRON LINES IN SY1 GALAXIES - CORRELATIONS WITH UV/OPTICAL SPECTRAL PROPERTIES

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The iron lines, which arise from a complex Fe II ion, are very interesting features in AGN spectra. There are many open questions connected with these lines: mechanisms of their excitation, location of their emission region in AGN structure, as well as correlations with other spectral properties, which physical cause is unknown.

We present a study of optical Fe II emission in a sample of AGNs selected from the SDSS. An optical Fe II template is calculated, with taking into account the lines from the strongest Fe II multiplets and an additional group of lines, based on a reconstruction of the spectrum of I Zw 1. This Fe II template gives a more precise fit of the Fe II lines than other templates (Kovacevic et al. 2010). We examine the relationships between different groups of iron multiplets and some optical and UV spectral properties. We investigate the dependence between Baldwin eect and well-known anticorrelation between Fe II and [O III] lines, which dominates in Boroson and Green's Eigenvector 1 (Boroson Green 1992). The possible influence of starburst regions on observed correlations is analyzed (Popovic Kovacevic 2011). Also, we investigate the relationships between some properties of UV spectra (near Mg II), and optical lines (in preparation).

1. Kovacevic, J., Popovic, L. C., Dimitrijevic, M. S., 2010, ApJS, 189, 15. 2. Popovic, L. C., Kovacevic, J., 2011, ApJ, 738 , 68.

PROGRAM OF THE 5th SCSLSA
(Vršac: June 06 - 10, 2005.)

Monday, 06. 06. 2005.

9:00-12:00 *Transportation (from Belgrade to Vršac by bus) and accommodation of participants.*

12:00-12:30 Opening Ceremony

Chairman: M.S. Dimitrijević

12:30-13:00 John Danziger: ”The role of line profiles in analyzing spectra of supernovae”
13:00-13:30 Zoran Petrović: ” Anomalous Doppler broadening of hydrogen lines due to excitation by fast neutrals in low pressure Townsend discharges”

13:30-15:30 *Lunch*

Chairman: Z. Petrović

15:30-16:00 Albert Ellingboe: ”Whistler wave - particle interaction in a temperate ionosphere-like plasma”
16:00-16:30 Nebil Ben Nessib: ”Interaction Potentials for Spectral Line Shapes in Plasma”
16:30-16:45 Zoran Simić: ”Influence of impacts with charged particles on Cd I and F III spectral lines in stellar plasma”
16:45-17:00 Walid Foued Mahmoudi: ”Semi-Classical and Modified Semi-Empirical Impact Stark Broadening Calculations of Singly-Ionized Carbon and Oxygen Spectral Lines”
17:00-17:15 Vladimir Milosavljević: ”Measured Stark Shifts of Kr I Line Profiles in the 5s-5p and 5s-5p’ Transitions”
17:15-17:30 Sergey Kharintsev: ”Fractional oscillator and anomalous Brownian motion in the theory of spectral line broadening and shift”

17:30-18:00 *Coffee break*

Chairwoman: D. Calzada-Canalejo

18:00-18:15 Magdalena Christova: ”Stark broadening of Ar I spectral lines emitted in surface-wave sustained discharges”
18:15-18:30 Haykel Elabidi: ”Electron impact broadening of multicharged neon spectral lines”
18:30-18:45 Bratislav M. Obradović: ”The external magnetic field influence on the hydrogen Balmer profiles in electric discharges”
18:45-19:00 Nenad Milovanović: ”The Stark Broadening Effect in Hot Star Atmospheres: Tl II”

19:00-20:30 Welcome cocktail

Tuesday, 07. 06. 2005.

Chairman: E. Barron

9:00-9:30 France Allard: ”The Importance of Alkali Line Broadening in Brown Dwarf Atmospheres”
9:30-10:00 Gillian Peach: ”Line Shapes for the Spectra of Brown Dwarfs”
10:00-10:30 Emanuil Danezis: ”A new modeling approach for DACs and SACs regions in the atmospheres of hot emission stars”
10:30-11:00 Denis Shulyak: ”Atmospheres of CP stars: magnetic field effects”

11:00-11:30 *Coffee break*

Chairman: A.F. Zakharov

11:30-12:00 Andrei Lobanov: ”Radio Spectroscopy of Active Galactic Nuclei”
12:00-12:30 Stefano Ciroi: ”The Hidden Nature of Narrow-Line Seyfert 1 Galaxies”
12:30-12:45 Dragana Ilić: ”Kinematics of the BLR and NLR in AGN Mrk 817”
12:45-13:00 Alexey Moiseev: ”Scanning Fabry-Perot interferometer in the extragalactic researches”
13:00-13:15 Edi Bon: ”Kinematics and Variability of III Zw 2 broad line emission region”
13:15-13:30 Srdjan Samurović: ”Detection of Dark Matter in Early-type Galaxies with X-ray Halos using Absorption Spectral Lines”

13:30-15:30 *Lunch*

Chairman: L. Wisotzki

15:30-16:00 Alexander F. Zakharov: ”Black Holes: Theory versus observations - Analysis of the Fe K_α Lines and Precise Astrometrical Observations”
16:00-16:30 Evencio Mediavilla, Cristina Abajas: ”Influence of Gravitational Microlensing on the Shapes of the QSO Emission Lines”
16:30-16:45 Predrag Jovanović: ”Microlensing effect on Fe Kα line and X-ray continuum in the case of three gravitationally lensed quasars: MG J0414+0534, QSO 2237+0305 and H1413+117”
16:45-17:00 Eleni Chatzichristou: ”Multi-Wavelength Surveys of Obscured AGN”

17:00-17:30 *Coffee break*

Chairman: M. Roth

17:30-18:00 Lutz Wisotzki: ”Quasar Absorption Lines and the Intergalactic Medium”
18:00-18:15 Marko Krčo: ”HINSA as a tool for studying dark clouds and star formation”

18:15-19:30 Poster presentation (5 min per poster)

Chairman: N. Ben Nessib

A. Vorobyev: ”Analytical curves reduction by using fractional derivative spectrometry”
B. Zmerli: ”Temperature dependence of non hydrogenic atom-lines Stark widths”
C. García: ”Gas temperature from line broadening in a neon microwave plasma at atmospheric pressure”
C. Yubero: ”Computer-simulated Balmer alpha line profile for calculating the electron number density”
M. S. Dimitrijević: ”On the influence of Stark broadening of Cr I lines in the Cr-rich Ap star β CrB atmospheres”
M. Christova: ”Calculations of the collisional neutral line widths of several Ar I lines”
M. C. García: ”Voigt damping parameter of the spectral lines emitted by a plasma flame and a plasma column generated by microwave at atmospheric pressure”
M. C. García: ”Self-absorption effects in the equivalent width of the spectral lines in a neon microwave plasma at atmospheric pressure”
R. Hamdi: ”Electric dipole transition probabilities in Al IV and Al V ions”
D. Korcakova: ”Emergent line profiles from rapidly rotating stars”
A. Dorodnitsyn: ”Line-driven winds near BHs”
F. Di Mille: ”Spectrophotometric study of nearby Seyfert nuclei”
A. Smirnova: ”Studying of some Seyfert galaxies by the methods of panoramic spectroscopy”
A. Lalović: ”The reduction of eclipsing binary stars spectra observed at Rožen Observatory”
N. Gavrilović: ”Investigation of rotational velocity of epsilon Persei”
B. Arbutina: ”A study of close binary system EE Cet”
Z. Simic: ”On the Stark broadening parameters for Cu III and Zn III lines in A type star atmospheres”

Wednesday, 08.06.2005.

Chairman: J. Purić

10:00-10:30 Valiants M. Astashynski: ”Spectroscopic study of plasma flows created by a magnetoplasma compressor”
10:30-11:00 Dolores Calzada-Canalejo: ”Spectroscopy of the discharges created and maintained by a surface-wave”

11:00-11:30 Coffee break

Chairman: J. Danzinger

11:30-12:00 Martin Roth: ”3D spectroscopy of emission line spectra of Planetary Nebulae: diagnostic tools from the Milky Way to nearby galaxies and beyond”
12:00-12:30 Eddie Baron: ”Overview of supernova modeling with Phoenix”

12:30-14:00 *Lunch*

14:00-19:00 *Visiting orthodox and catholic churches in Vršac, monastery Mesić, Vršac's Tower (at the top of Vršac's mountains)*

20:00-23:00 *Visiting the wine cellar in the village Gudurica with testing local wines. Conference dinner.*

Thursday, 09.06.2005

Chairwoman: G. Peach

11:00-11:30 Peter Hauschildt: "Effects of line profiles in T dwarfs"
11:30-12:00 Mikhail Sachkov: "Pulsations in the Atmospheres of Ap stars"
12:00-12:15 Olga Atanacković-Vukmanović: "Solution of NLTE line transfer problem by use of a forth-and-back implicit Λ iteration"
12:15-12:30 Milan Zboril: "Helium line shape analysis in B type stars"
12:30-13:45 Darko Jevremović: "^{6}Li in the quiescent atmospheres of active cool stars"

13:45-15:30 *Lunch*

Chairman: P. Hauschild

15:30-16:00 Milan S. Dimitrijević: "Processes of atom-atom (n - n') - mixing influence on hydrogen atom Rydberg states populations in stellar atmospheres"
16:00-16:30 Evangelina Lyratzi: "A new approach for the structure of Hα regions in 120 Be stars"
16:30-16:45 Nikola Vitas: "Heights of formation of Mn I spectral lines broadened by hyperfine structure"
16:45-17:00 Derek Homeier: "Molecular Line Widths at Stellar Atmosphere Conditions"

17:00-17:30 *Coffee break*

Chairman: E. Danezis

17:30-18:00 Slobodan Ninković: "Globular Clusters of the Milky Way: Their fate and chemical composition"
18:00-18:15 Nenad Sakan: "The application of the cut-off Coulomb potential for the calculation of a continuous spectra of dense hydrogen plasma"

Chairmans: M. S. Dimitrijević, L. Č. Popović

18:15-19:00 Discussion about conference, next SCSLSA, all participants are invited to take part.

Friday, 10. 06. 2005.

Excursion: Smederevo Fortress (1420), monastery Manasia (1407), Resava cave, waterfall Lisine
Back to Belgrade around 21:00

QUATRIEME SEMINAIRE FRANCO-POLONAIS SUR
LES PLASMAS THERMIQUES
DANS L'ESPACE ET EN LABORATOIRE

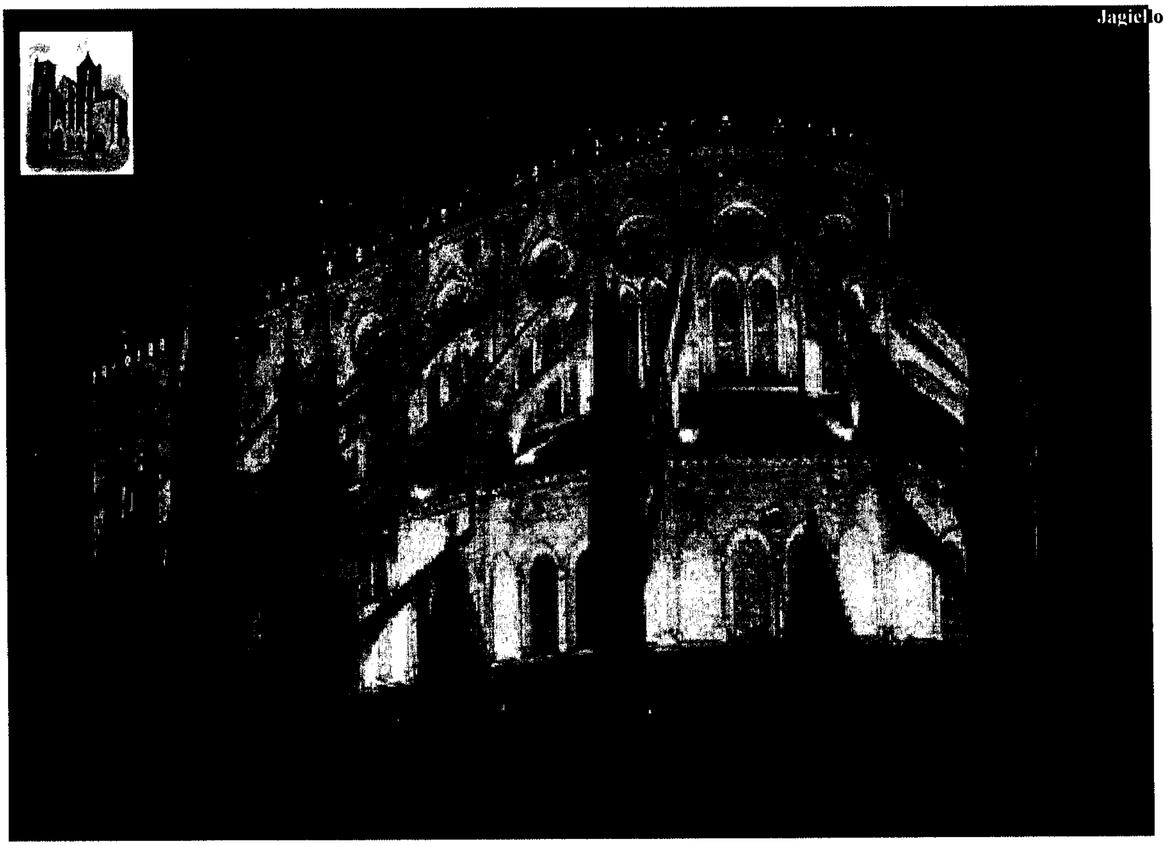
Bourges (France) - 16-19 juin 2003

Université
d'Orléans

Ce séminaire doit permettre d'accroître les échanges scientifiques entre la France et la Pologne dans le domaine des plasmas froids, allant de la physique fondamentale aux applications technologiques, et d'examiner les perspectives.

Il est soutenu par les Ambassades de France en Pologne et de Pologne en France, la Fédération EPEE Orléanaise, la Région Centre, le Conseil Général du Cher, la ville de Bourges et les Universités d'Orléans et Jagelonne.

Uniwersytet
Jagielloński



LASEP

Celem seminarium jest wzmocnienie wymiany naukowej pomiędzy Francją a Polską w dziedzinie chłodnej plazmy, w zakresie badań fundamentalnych, zastosowań technologicznych oraz przegląd perspektyw dalszej współpracy.

Organizacja seminarium była możliwa dzięki wsparciu finansowemu Ambasady Francuskiej w Warszawie i Polskiej w Paryżu, la Fédération EPEE Orléanaise, la Région Centre, le Conseil Général du Cher, la ville de Bourges, Uniwersytetu w Orleanie oraz Uniwersytetu Jagiellońskiego.

Bourges (France) – 16-19 czerwiec 2003

CZWARTE SEMINARIUM POLSKO-FRANCUSKIE
PLAZMA TERMICZNA
W PRZESTRZENI KOSMICZNEJ I LABORATORIUM

POSTER II.15.

POSZERZENIE STARKA LINII ArI

L'ELARGISSEMENT STARK DANS LE SPECTRE DE ArI

Vladimir MILOSAVLJEVIĆ, Stevan DJENIŽE
Faculty of Physics, University of Belgrade, P.O.B. 368, Belgrade, Serbia and Montenegro

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Poszerzenie Starka linii spektralnych Ar I odgrywa ważną rolę w diagnostyce plazmy laboratoryjnej, plazmy wytworzonej laserem czy plazmy stosowanej w różnego typu procesach technologicznych oraz w ich modelowaniu. Linie Ar I jak również innych pierwiastków śladowych odgrywają coraz większą rolę w astrofizyce. Dzieje się tak wskutek rozwoju teleskopów kosmicznych i takich urządzeń jak wysokiej zdolności rozdzielczej spektrograf Goddarda zainstalowany na teleskopie Hubble'a. Na przykład w ciągu ostatnich kilku lat linie absorpcyjne Ar I zostały zarejestrowane w widmie gwiazdy podwójnej Wolf-Rayet SK 108, PG 1259+593 a także w widmach innych obiektów kosmicznych jak kwazar Q0347-3819 i kometach.

Na podstawie precyzyjnie zarejestrowanych kształtów linii neutralnego argonu (przejścia 4s-4p) otrzymaliśmy ich parametry poszerzenia jonowego (A) i wyznaczyliśmy wpływ dynamicznego efektu jonowego (D) na kształt linii. Ponadto wyznaczyliśmy przyczynki elektronowy (We) i jonowy (Wi) do całkowitego poszerzenie Starka. Odkryliśmy silniejszy wpływ przyczynku jonowego na profile linii Ar I niż to wynika z obliczeń teoretycznych.

L'élargissement Stark des raies spectrales du Ar I a un grand intérêt pur le diagnostic, la modélisation et la recherche dans le domaine des plasmas de laboratoire, produits par laser et technologiques. Grâce au développement des télescopes cosmiques, et des expériences comme le Spectrographe Goddard de haute résolution sur le télescope cosmique Hubble, les raies spectrales du Ar I, comme les autres éléments à l'état de traces, ont un intérêt croissant également en astrophysique. Par exemple pendant les quelques dernières années, les raies d'absorption du Ar I ont été trouvée dans les spectres des binaires Wolf-Rayet SK 108, PG 1259 + 593 et autres étoiles, mais également dans les spectres des autres objets cosmiques comme le quasar Q0347-3819 et les comètes.

En utilisant les mesures précises des cinqs profils des raies (dans le transition 4s-5p) de l'argon neutre, nous avons obtenu leur paramètre d'élargissement par les ions (A), et nous avons déterminé l'influence de l'effet du dynamique des ions (D) au profil de la raie spectrale. Les contributions électronique (We) et ionique (Wi) à la largeur Stark totale, ont été obtenues séparément. Nous avons trouvé que l'influence de la contribution ionique aux profils des raies de Ar I, était plus importante que celle obtenues avec les approximations théoriques existantes.

QUATRIEME SEMINAIRE FRANCO-POLONAIS SUR
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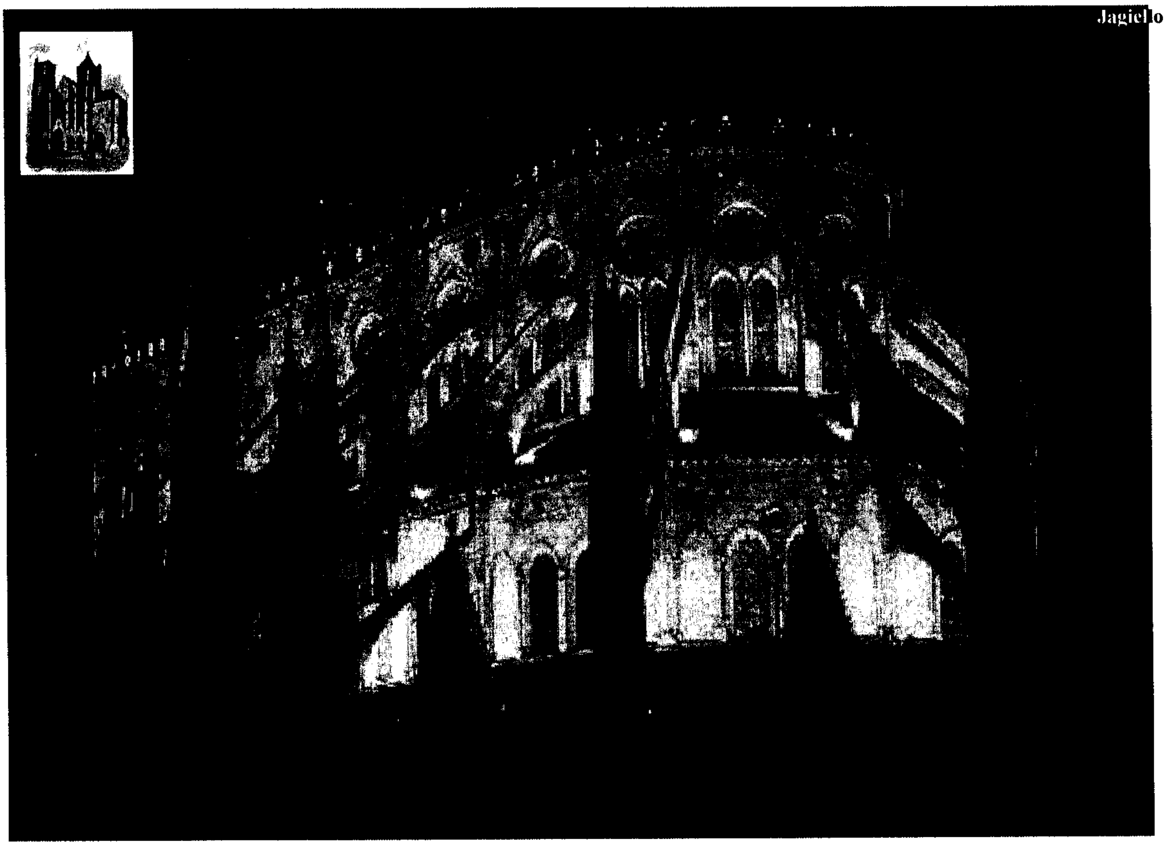
Uniwersytet Jagielloński



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Bourges (France) – 16-19 czerwiec 2003

CZWARTE SEMINARIUM POLSKO-FRANCUSKIE
PLAZMA TERMICZNA W PRZESTRZENI KOSMICZNEJ I LABORATORIUM

PRÉSENTATION ORALE .5.

POSZERZENIE STARKA LINII SPEKTRALNYCH

L'ELARGISSEMENT STARK DES RAIES SPECTRALES

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Badania przestrzeni kosmicznej (IUE, FUSE, LYMAN, HST, GHRS...) przyniosły nowe zapotrzebowanie na dane atomowe. Profile Starka (poszerzenia i przesunięcia) są ważne nie tylko z punktu widzenia diagnostyki, modelowania czy badań plazmy laboratoryjnej ale także odgrywają istotną rolę w badaniach plazmy występującej w przestrzeni kosmicznej.

Od 1978 roku współpracujemy m.in. z Nicole Feautrier, Veronique Bommier, Nebil Ben Nessib z Tunezji w dziedzinie starkowskich profili linii w zastosowaniu do badań astrofizycznych i laboratoryjnych. Wynikiem tej współpracy jest ponad 50 artykułów.

Przy użyciu półklasycznej metody perturbacyjnej wyznaczyliśmy parametry poszerzenia Starka dla dużej liczby linii spektralnych takich układów jak: He I, Na I, Li I, Ca I, Al I, Rb I, Mg I, Zn I, Se I, Sr I, Ca II, Be II, Li II, Mg II, Ba II, Si II, Al III, Sc III, Be III, Y III, In III, Tl III, Ti IV, Si IV, C IV, O IV, P IV, Pb IV, O V, P V, S V, V V, O VI, S VI, F VI, O VII, F VII, Cl VII, Ne VIII, Ar VIII, K VIII, Kr VIII, Ca IX, K IX, Na IX, Na X, Ca X, Sc X, Al XI, Si XI, Mg XI, Ti XI, Si XII, Ti XII, Si XIII, V XIII etc... W trakcie seminarium przedstawimy wyniki naszej współpracy.

L'Astronomie spatiale (IUE, FUSE, LYMAN, HST, GHRS...) a créé de nouveaux besoins de données de physique atomique et les profils Stark (largeurs et déplacements) sont importants pas seulement pour le diagnostic, la modélisation et la recherche dans le domaine des plasmas de laboratoire, produits par laser et technologiques, mais aussi pour des plasmas cosmiques.

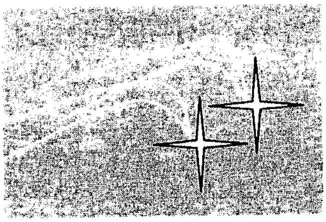
A partir de 1978 nous avons une collaboration dans le domaine de recherches "Profils Stark des raies spectrales d'intérêt astrophysique et de laboratoire", qui a donne lieu a plus de 50 publications depuis 1981 dans des revues scientifiques internationales et a laquelle ont participe aussi Nicole Feautrier, Véronique Bommier, Nebil Ben Nessib de Tunisie et les autres.

En utilisant la méthode semi-classique perturbation nous avons déterminé les paramètres de l'élargissement Stark d'un grand nombre des raies dans les spectres comme He I, Na I, Li I, Ca I, Al I, Rb I, Mg I, Zn I, Se I, Sr I, Ca II, Be II, Li II, Mg II, Ba II, Si II, Al III, Sc III, Be III, Y III, In III, Tl III, Ti IV, Si IV, C IV, O IV, P IV, Pb IV, O V, P V, S V, V V, O VI, S VI, F VI, O VII, F VII, Cl VII, Ne VIII, Ar VIII, K VIII, Kr VIII, Ca IX, K IX, Na IX, Na X, Ca X, Sc X, Al XI, Si XI, Mg XI, Ti XI, Si XII, Ti XII, Si XIII, V XIII etc... Nous présenterons une revue des résultats du notre collaboration.

4th Serbian-Bulgarian Astronomical Conference (IV SBGAC)
21-24 April 2004, Belgrade, Serbia

PROGRAM AND ABSTRACTS

ed. M. S. Dimitrijević



Belgrade Astronomical Observatory, Astronomical Society "Rudjer Bošković"
and "Inka", Tikveška 16

Belgrade 2004

4th Serbian-Bulgarian Astronomical Conference (IV SBGAC)
21-24 April 2004, Belgrade, Serbia

Organized by Belgrade Astronomical Observatory and
Astronomical Society "Rudjer Bošković"

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Valeri Golev (Co-chairman, Astronomical Observatory, Sofia)
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Tatjana Milovanov-Milenković (Astronomical Observatory, Belgrade)

CONFERENCE PROGRAMME:

April 21, Wednesday

12:00 Opening Ceremony

Chairman: *Milan S. Dimitrijević*
12:30 Peter Getsov: NEW OPPORTUNITIES FOR BULGARIAN SPACE RESEARCH

13:15 COCTAIL

Chairman: *Milcho Tsvetkov*
15:00-15:30 S. Jankov, R. Petrov, F. Vakili, S. Robbe-Dubois, A. Domiciano: HIGH ANGULAR RESOLUTION IN MODERN ASTRONOMY: NEW INSIGHTS INTO THE STELLAR PHYSICS

15:30-16:00 Katya Tsvetkova, Milcho Tsvetkov, Konstantin Stavrev, Ana Borisova: BALKAN COLLABORATION IN THE ARCHIVING OF WIDE-FIELD PHOTOGRAPHIC OBSERVATIONS

16:00-16:30 Milan S. Dimitrijević: FULLERENES AND ASTRONOMY

16:30-17:00 Georgi Ivanov: STAR COMPLEXES IN M33

17:00-17:30 Cofee break

Chairman: *Slobodan Jankov*
17:30-18:00 Rumen Bogdanovski: STARGAZER–WEB BASED SYSTEM FOR STAR FIELD VISUALISATION AND ITS INTEGRATION TO THE WFPDB

18:00-18:30 Dejan Urošević: THEORETICAL SIGMA-D RELATION FOR SUPERNOVA REMNANTS

18:30-19:00 Damyan Kalaglarski: WEB ACCESS AND IMAGE PROCESSING IN ASTROPHYSICAL DATABASES

19:00-19:30 Vladan Čelebonović: TWO SIMPLE PROBLEMS IN SEMICLASSICAL DENSE MATTER PHYSICS

April 22, Thursday

Chairman: *Luka Č. Popović*
9:30-10:00 Gojko Djurašević: INVESTIGATIONS OF ACTIVE CLOSE BINARY SYSTEMS ON BELGRADE ASTRONOMICAL OBSERVATORY

10:00-10:30 Lachezar Filipov: ACRETION DISKS: RESULTS OF SEARCH IN SPACE RESEARCH INSTITUTE - BULGARIA

10:30-11:00 P. Böhm, Th. Becker, M. M. Roth, M. Verheijen: 3D SPECTROPHOTOMETRY WITH PMAS

11:00-11:30 Cofee break

Chairman: *Georgi Ivanov*

11:30-12:00 Luka Č. Popović, Konstantin Y. Stavrev, Katya Tsvetkova, Milcho Tsvetkov, Dragana Ilić, Sebastian F. Sanchez, Gotthard M. Richter, Petra Böhm: OBSERVATIONS OF AGNs WITH THE 2m TELESCOPE OF ROZHEN OBSERVATORY: AIMS AND PRELIMINARY RESULTS

12:00-12:30 Valeri Golev, Ivanka Yankulova: THE STARBURST-AGN CONNECTION FOR THE IR Sy2 GALAXY MARK 534 = NGC 7679

12:30-13:30 Cofee break with snacks

Chairman: *Slobodan Ninković*

13:30-15:30 Poster presentation (First 14 posters) (5-10 min for each poster)

A walk through Belgrade

18:30 Visit of Belgrade Astronomical Observatory

19:30 CONFERENCE DINNER IN THE "BELI BAGREM" RESTAURANT
(850 din for non sponsored participants)

April 23, Friday

8:00-22:00 FULL DAY EXCURSION

Visits of SMEDEREVO with SMEDEREVO FORTERESS ancient capital of medieval Serbia, VRSHAC with Ancient Farmacy from 1784 with the collection of works of famous Serbian painter Paja Jovanovic, Vrshac medieval tower, Ortodox cathedral of St. Nicholas from 1785, Catolic cathedral of St. Gerhard from 1861, Vladika's court from 1757, MESIC Monastery with the church of "St. Jovan Pretecha" from 1225.

April 24, Saturday

Chairman: *Valeri Golev*

9:30-10:00 Slobodan Ninković: GLOBULAR CLUSTERS-INTERESTING STELLAR SYSTEMS

10:00-10:30 Zorica Cvetković: EUROPEAN LONGITUDE NETWORK AND A PROJECT FOR THE BELGRADE INCLUSION

10:30-11:00 Miodrag Dačić: REDUCTION OF ASTROGEODETIC DETERMINATIONS ON THE UNIQUE SYSTEMS

11:00-11:30 Cofee break

Chairman: *Katya Tsvetkova*

11:30-13:30 Poster presentation (Posters from the 15th)

13:30 Closing of the Conference

Official languages of the Conference are Serbian, Bulgarian and English. Proceedings of the IV SBGAC will be published until the end of 2004 and the deadline for manuscripts of invited lectures and contributed papers is 1st June 2004. There is no limitations on the number of pages, but contributions will be reviewed by SOC and if too extensive a shorter version will be requested.

Contributions should be sent to the E-mail address:
mdimitrijevic@aob.bg.ac.yu
or, if dificulties with e-mail connections, to
lpopovic@aip.de
or by mail to
Milan S. Dimitrijević
Astronomical Observatory
Volgina 7
11160 Belgrade
Serbia
tel. +381 11 419357 / 117
fax. +381 11 2419553

TeX macros file for papers may be obtained from Predrag Jovanović
pjovanovic@aob.bg.ac.yu

On Internet address http://www.aob.bg.ac.yu/meetings/4scsls you can also download papers macros.

IV Serb. Bulg. Astron. Conf.
Belgrade 21–24. April 2004.
Program and Abstracts

Invited lecture

REDUCTION OF ASTROGEODETIC DETERMINATIONS ON THE UNIQUE SYSTEMS

MIODRAG DAČIĆ
Astronomical Observatory, Volgina 7, 11160 Belgrade – 74, Serbia
E-mail mdacic@aob.bg.ac.yu

Determinations in geodetic astronomy, namely, determination of time, longitude, latitude and azimuth from star observations, have been made during a long period by different persons. Positions of observed stars have been taken from different catalogues and in different reference systems. In order that results of such determinations will be mutually comparable, it is necessary to make the reduction of stellar positions on the unique reference system. Consequently, results of astrogeodetic determinations will also be reduced to the same system. Starting from the fact that the position of a point is determined only related to something, it is possible to calculate systematic differences of particular catalogues and catalogues used for the materialisation of the chosen reference system. Obtained stellar positions-, and proper movements - systematic errors, enable the changement from standard epoch on another one (the moment of observation), so that stellar positions are reduced to a single system. The proposed model is checked at three classical methods of geodetic astronomy and applied to results of general Stevan Bošković's astrogeodetic determinations, made in the first decade of the XX century.

Invited lecture

FULLERENES AND ASTRONOMY

MILAN S. DIMITRIJEVIĆ
Astronomical Observatory, Volgina 7, 11160 Belgrade – 74, Serbia
E-mail mdimitrijevic@aob.bg.ac.yu

Carbonaceous dust in the interstellar medium may show strong diversity and might include not only amorphous carbon but also a variety of components like hydrogenated amorphous carbon, soot, quenched-carbonaceous condensate, diamonds and other so that is pointed out the relation of formation of PAHs, bucky tubes and fullerenes to such dust. We note as well that the astrophysically motivated investigations of the chemistry of carbon stars resulted with the discovery of the C_{60} molecule, first and the most interesting representative of such molecules. Here is presented a review of astronomical researches connected with fullerenes as for example the search for interstellar and circumstellar ones or presence of such molecules in meteorites brechias of impact craters on Earth and impact traces on spacecrafts. Also, their connection with the problem of the diffuse interstellar and circumstellar absorption lines will be discussed. Particular attention will be payed to the search for polyynes in interstellar space which resulted in the formulation of investigation of chemistry of carbon stars and in discovery of fullerenes.

Poster paper

WATER IN ASTRONOMY AND PLASMA PHYSICS AND A PROJECT FOR RELATED RESEARCH

NEGICA POPOVIĆ[1], MILOŠ SIMIČIĆ[1], JOVANA SIMIĆ-KRSTIĆ[1],
MILAN S. DIMITRIJEVIĆ[2]
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The importance of water, the dissolvent without whom our kind of life would be impossible, is obvious and the research of all aspect of this compound is of great interest for many sciences. In astronomy, water is found in comets, Jovian satellites, on the Mars... The first molecule to be detected by radio astronomy methods, was the radical OH in 1963. Some OH sources in interstellar H II regions show strong H_2O emission as well. Their H_2O emission is variable, with intensity changes occuring in periods of months and days. In such regions temperature is around 10000 K and ion density around 5000 ions on m^3. Waters molecules are found and in OH-IR stars, which are probably dust enshrouded Myras having period 600 - 2000 days, and are not visible optically. Recently, water molecules have been detected in the mid-infrared (11-12 microns) spectrum of Arcturus, a K2IIIp giant star *(Ryde, N., et al. 2003). Moreover, water at 22,235 MHz (1,35 cm) is one of the well known* cosmic masers. Plasma obtained from H_2O is of interest and for investigations of underwater discharges, some aspects of electrolysis research, and for various treatments of water. In this contribution, our project for investigations of plasma-water interaction, plasma containing water molecules, or obtained in the presence of water molecules, of interest for astronomy, laboratory physics and technology, will be discussed.

Poster paper

TEMPORAL VARIABILITY OF THE GRB LIGHT CURVE

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[2]*Astronomical Observatory, Volgina 7, 11000 Belgrade – 74, Serbia*
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[3]*Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany*

The inner engines of Gamma Ray Bursts (GRBs) are well hidden from direct afterglow observations. However, the variability of GRB light curves at beginning of GRB event can bring us information about the nature of the inner engines. Here, we will present a numerical model which can synthesize light curves in the first phase of GRB in the high density environment. At the beginning we assume that an inner engine creates a lot of small mass shock waves which are spreading isotropically and after short period of time (a couple of seconds) disappearing in the surrounding media. This process causes creation of a massive shock wave which interacts with surrounding media and produces the GRB afterglow. The peaks in the light curve arise in the moment of mutual shocks interaction. We have modeled light curves from a given dynamics, by assuming synchrotron radiation mechanism

**IV Serb. Bulg. Astron. Conf.
Belgrade 21–24. April 2004.
Program and Abstracts**

Poster paper

ON THE STARK BROADENING OF F III LINES IN WHITE DWARF ATMOSPHERES

ZORAN SIMIĆ, MILAN S. DIMITRIJEVIĆ, LUKA Č. POPOVIĆ
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E–mail lpopovic@aob.bg.ac.yu

In order to provide the Stark broadening parameters for F III spectral lines, we made first of all a model of F III atom, with symplified energy level structure, facilitating and optimizing our further considerations. We applied full semiclassical perturbation method only to the astrophysically most important, resonance transition, since for other lines there is no enough complete set of atomic data for such calculations. Consequently, for additional ten multiplets, the modified semiempirical method has been applied, and only Stark widths have been calculated. On the basis of obtained results, the influence of Stark broadening mechanism on F III lines in DA white dwarfs has been investigated. The obtained results demonstrate that it is more important than in A-type star atmospheres, and that it should be taken into account for spectrum analysis and synthesis.

Poster paper

ON THE STARK BROADENING OF Cd I LINES

ZORAN SIMIĆ[1], MILAN S. DIMITRIJEVIĆ[1], SYLVIE SAHAL-BRÉCHOT[2]
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E–mail Sylvie.Sahal-Brechot@obspm.fr

For the determination of chemical composition and plasma diagnostic of stellar atmospheres, as well as for radiative transfer, plasma modelling and stellar spectra interpretation and synthesis, Stark broadening parameters are of interest, especially for A-type stars and some white dwarfs, or pre dwarfs like PG-1195 type ones. In order to provide the Stark broadening data for neutral cadmium spectral lines, we have calculated within the semiclassical perturbation theory, Stark broadening parameters (width and shift) for 19 Cd I multiplets in UV and V and for 24 multiplets in infra red spectral ranges, for temperatures between 2500 K and 50 000 K, particularly interesting for stellar plasma investigations. Our theoretical values have been compared with existing experimental, and other theoretical values.

IV Serb. Bulg. Astron. Conf.
Belgrade 21–24. April 2004.
Program and Abstracts

Poster paper

ON THE EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF F II STARK BROADENING

ALEKSANDAR SREĆKOVIĆ[1], SRDJAN BUKVIĆ[1], STEVAN DJENIŽE[1],
MILAN S. DIMITRIJEVIĆ[2]

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Stark widths (W) and shifts (d) of 5 singly ionized fluorine (F II) spectral lines within the $3s - 3p, 3s' - 3p'$ and $3d - 4f$ transitions have been measured in a linear, low-pressure, pulsed arc discharge created in SF_6 plasma at 30400 – 33600 K electron temperatures and at $(2.75 - 2.80) \times 10^{23}$ m^{-3} electron densities. The widths and shifts have also been calculated using the semiclassical perturbation formalism (SCPF) (taking into account the impurity of energy levels, i.e. that the atomic energy levels are expressed as a mix of different configurations due to the configuration interaction). Calculations have been performed for temperatures between 5 000 K and 100 000 K for the for electrons, protons and helium ions as perturbers. Our measured and theoretical Stark parameters are compared with existing experimental and theoretical data. Tolerable agreement was found among them.

Poster paper

CALIBRATION OF THE DIAMETER TULLY-FISHER RELATION AS TOOL FOR DISTANCE DETERMINATION TO SPIRAL EDGE-ON GALAXIES

ORLIN STANCHEV, PETKO NEDIALKOV, ISKREN GEORGIEV

Institute of Astronomy, Bulgarian Academy of Sciences,
72 Tsarigradsko Shosse Blvd., BG-1784 Sofia, Bulgaria
E-mail stanchev@astro.bas.bg

The luminosity - HI line width relation of (Tully and Fisher 1977), hereafter TFR, is a widely used tool in the observational cosmology. Today, with the advent of the CCDs, the application of the TFR becomes more efficient. In this work we present calibrated TFR for the diameters of well studied nearby galaxies in B-band (from Macri et al. 2000) and apply it on the sample of 120 edge-on galaxies Karachentsev et al. (1992). The calibration was made after reducing the linear diameters of the calibrators into edge-on view. Using the derived TFR, the distances to the galaxies from the target sample are calculated and compared with kinematic distances. The distance modulus error, of the derived calibration is about 0.45 mag, and the relative distance error is 21%.

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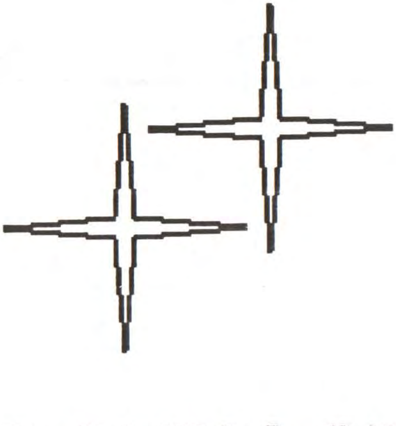

SPACE SCIENCE

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Influence of Collisions with Charged Particles on Spectral Line Shapes. Research at the Belgrade Astronomical Observatory

M.S. Dimitrijević

Astronomical Observatory, Volgina 7, 11160, Belgrade, Serbia

Starting with 2002 up to 2005, Ministry of Science and Environment protection of Republic of Serbia financed the project "Influence of collisions with charged particles on spectral line shapes". The contract for the project under same name is signed also for the 2006-2010 period. The objective of this contribution is to review the results obtained up to now and to discuss the future plans in order to stimulate the development of Serbian–Bulgarian collaboration within this research field.

Analysis of the WFPDB ROB033 Catalogue

K. Tsvetkova[1], **M. Tsvetkov**[1], **D. Kalaglarsky**[2], **P. Lampens**[3], **D. Duval**[3]

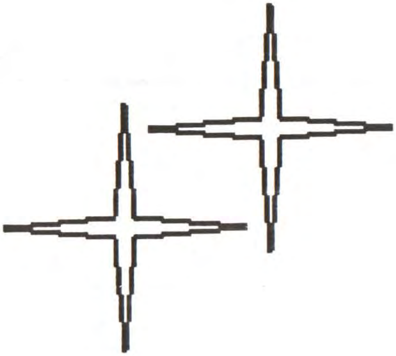
[1]Institute of Astronomy, Bulgarian Academy of Sciences
[2]Space Research Institute, Bulgarian Academy of Sciences
[3]Royal Observatory of Belgium

We present the incorporated recently in the Wide-Field Plate Database (WFPDB) catalogue of the Royal Observatory of Belgium (ROB) Carte du Ciel plates. The catalogue comprises the descriptive information about 660 plates obtained in the frames of the Carte du Ciel project in the period 1908–1939 with the Equatorial Gautier 0.33m telescope. The analysis of the catalogue is present. The catalogue, as well as plate previews, taken with 250 dpi resolution, are available online at `http://www.skyarchive.org/`.

Programme & Abstracts

The 5th Bulgarian-Serbian Conference on

ASTRONOMY



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On the Stark Broadening of Visible Ar I Lines for Astrophysical Plasma Analysis and Modelling

M. Christova[1], **M.S. Dimitrijević**[2], **S. Sahal-Bréchot**[3], **N. Andreev**[1]

[1]Department of Applied Physics, Technical University of Sofia,
1000 Sofia, Bulgaria
[2]Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia
[3]Observatoire de Paris, LERMA-Meudon, F-92195 Meudon Cedex, France

With the development of space-born spectroscopy, the importance of atomic data, including the Stark broadening parameters, for trace elements like argon, increases. For example argon is found in CVn binary σ^2 Coronae Borealis, and "Chandra's" X-ray spectra of young supernovas 1998S and 2003bg revealed argon over-abundance. Recently, argon lines are observed in the optical spectrum of the B_e star Hen 2-90, as well as in planetary nebulae and H II regions in the two dwarf irregular galaxies Sextans A and B. Consequently, Stark line broadening parameters for neutral and ionized argon are of interest for the modeling and investigation of astrophysical plasmas. Particularly significant are lines within the optical spectral range and we will investigate here Stark broadening of just such lines of neutral argon.

The Stark parameters (width and shift) of six Ar I spectral lines within the optical part of the spectrum: 522.1, 549.6, 518.6, 603.2 and 696.5 nm corresponding to the transitions $3p^5nd \rightarrow 3p^54p$ for $n = 7$–5 and $4p' \rightarrow 4s$ have been calculated within the semi-classical perturbation approach. The results have been compared with calculated and experimental data of other authors. The various limits of applicability of obtained results are also investigated in detail. We will present here, as an example, data for 696.5 nm Ar I spectral line.

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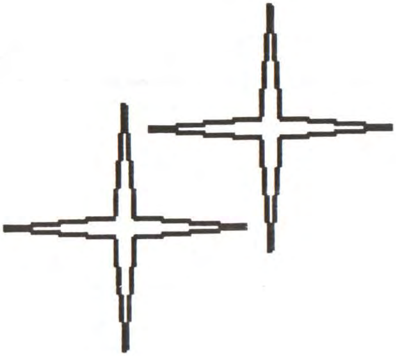

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Cowan Code and Data for Spectral Line Broadening Parameters

N. Milovanović, **M.S. Dimitrijević**

Astronomical Observatory, Volgina 7, 11160, Belgrade, Serbia

Cowan code is a program for ab initio non-relativistic atomic parameters calculations. For a better precision of Stark broadening parameter calculations within the semiclassical perturbation, and modified semiempirical approaches we need a sufficiently complete set of atomic data. With the Cowan code it is possible to obtain missing atomic energy levels and to calculate needed oscillator strengths with better precision than within Coulomb approximation. Using combinaton of experimental and theoretical atomic parameters, calculated by Cown code, we present Stark broadening data of spectral lines of S I, S II, S III, S IV and S V within the modified semiempirical approach. Also we compare and discuss differences when Cowan code and Coulomb approximation are used.

Are There Faint Fuzzy Clusters Counterparts in the Magellanic Clouds?

P. Pessev[1,2]

[1]Space Telescope Science Institute, USA

[2]Department of Astronomy, St. Kliment Ohridski University of Sofia

Faint Fuzzies (FFs) were serendipitously discovered during a study of the Globular Cluster system of the S0 galaxy NGC1023. They are a population of faint ($Mv > -7$), extended ($R_{\text{eff}} \sim$ 7–15 pc) clusters. Similar objects were also found around other S0 galaxies: NGC 3384, NGC 5195 and ~25% of the S0s in Virgo Cluster. Numerical simulations suggest that the required conditions to form such clusters may occur during close galaxy-galaxy interactions, thus the Magellanic Clouds are the nearest galaxies that could harbor a population of local counterparts of the FFs. In the present paper we discuss our criteria, search strategy and present some preliminary results of the project.

Programme & Abstracts

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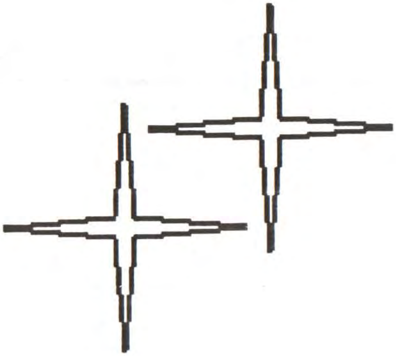

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Stark Broadening Mechanism in Hot Stellar Atmospheres

Z. Simić, M.S. Dimitrijević, L.Č. Popović, M.D. Dačić

Astronomical Observatory, Volgina 7, 11160, Belgrade, Serbia

Stellar spectroscopy needs atomic and line-broadening parameters for a very extensive list of line transitions for various elements in neutral and ionized states. With the development of space-born observational techniques data on trace elements become more and more important for astrophysical problems as stellar plasma analysis and modeling, stellar opacity calculations and, interpretation and numerical synthesis of stellar spectra. In several works we investigated Stark broadening mechanism in atmospheres of A type stars and DB and DA white dwarfs. Here, we discuss the importance of Stark broadening data for stellar atmospheres plasma research on the basis of our results for spectral line widths of Cd I, F III, Cu III, Zn III and Se III transitions, obtained within the modified semi empirical approach and semi classical perturbation method.

Probing the M31 Opacity through Galaxies behind Its Disk

A. Valcheva[1], V. Ivanov[2], L. Vanzi[2], P. Nedialkov[1]

[1]Department of Astronomy, Faculty of Physics, Sofia University

[2]European Southern Observatory

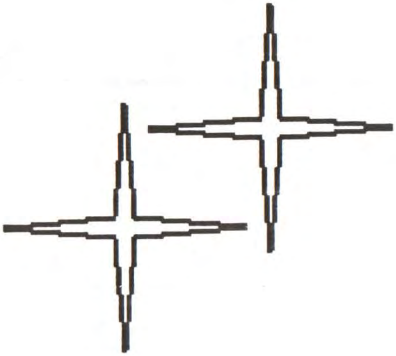
We obtained IR CCD images with 1.83 m Vatican Advanced Technology Telescope (VATT) at Mt. Graham International Observatory, USA in order to perform HK photometry for a sample of 21 galaxies seen through the disk of M31. Most of the galaxies exhibit prominent bulges and the sample is representative for galactocentric distance of $r \sim 20$ arcsec (7 galaxies) and $r \sim 90$ arcsec (14 galaxies) all within isophotal diameter of 26 mag/sq.arcsec. Reasonable consistency between the colors derived by us and the 2MASS colors was found. Neglecting the k-corrections and assuming a constant true color $(H-K)_0 = 0.22$ lead to overestimated $E(B-V)$ not correlated with the gas column densities. Such a contradiction can be overcome if chemically consistent evolutionary models of Bicker *et al.* [1] are taken into account.

[1] J. Bicker, U.v.A. Fritze, K.J. Fricke (2003) *Astr. & Sp. Sci.* **284**, 463 (Evolutionary synthesis models for galaxy transformation in clusters).

Programme & Abstracts

The 5th Bulgarian-Serbian Conference
on

ASTRONOMY



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Bulgarian–Serbian Cooperation in Astronomy: The Development over the Last 10-Years

M.S. Dimitrijević[1], **M.K. Tsvetkov**[2]

[1]Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia
[2]Institute of Astronomy, BAS, 72 Tsarigradsko Shosse, 1784-Sofia, Bulgaria

Present Fifth traditional conference on astronomy is result from active contacts and joint search programs between Bulgarian and Serbian astronomers during last 10 years. In the talk is summarized briefly main results from the four joint conferences held in Belogradchik (Bulgaria), Gamzigrad (Serbia), Gjolechitsa (Bulgaia) and Belgrade. We report the rising interest to participation in the conferences from both sides and also from astronomers from other European countries. Bulgarian-Serbian bilateral contacts in astronomy are on the bases of the renewed bilateral collaboration between Bulgarian and Serbian Academies of Sciences as well as the regional Balkan collaboration in Astronomy and Space sciences and programs supported by the UNECO. This 5th conference with more than 75 participants confirm the tendency of enlargement of the Bulgarian-Serbian joint work in Astronomy and Space Sciences.

Regional European Space Research Projects: SURE, GMES, BALKANSAT

L. Filipov

Space Research Institute, Bulgarian Academy of Sciences

In this paper, it is presented the European Space Programs GMES, SURE, BALKANSAT, the possibilities of the Bulgarian participation, particularly the Space Research Institute and how these programs may help to improve the quality of life in the planet and especially in the region. SURE is a program of the European Space Agency (ESA) and its aim is to ensure science devices and performing the experiments at the International Space Station (ISS) as included the East European countries. The essence of the program of Global Monitoring of the Environment and Security (GMES) is the data integration received from space, air, earth and sea platforms for regional and global monitoring. This program is created to resolve the problems of the population and economics. The project BALKANSAT includes the creating of micro-satellite platform loaded with necessary appliance on its board and performing the relevant experiments, mostly applicable of the environment examination. The cooperation and establishment the Bulgarian-Serbian joint network is discussed.

Fifth General Conference of the Balkan Physical Union BPU-5

Vrnjačka Banja, Serbia and Montenegro, August 25-29, 2003

Editors:

S. Jokić, I. Milošević, A. Balaž, Z. Nikolić

Book of Abstracts

Serbian Physical Society, 2003

SP08 - 201

STARK SHIFTS DEPENDENCE ON THE UPPER LEVEL IONISATION POTENTIAL AND THE REST CORE CHARGE OF THE EMITTER WITHIN ns-np TRANSITION ARRAYS

MARA ŠĆEPANOVIĆ AND JAGOŠ PURIĆ*

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*Faculty of Physics, University of Belgrade, P. O. Box 364, 11001Belgrade, Serbia and Montenegro

Stark shift simultaneous dependence on the upper level ionization potential and rest core charge of the emitter has been evaluated and discussed. It has been verified that the found relations, connecting Stark broadening parameters with upper level ionization potential and rest core charge of the emitters for particular electron temperature and density, can be used for prediction of Stark line width and shift data in case of ions for which observed data, or more detailed calculations, are not yet available. Stark widths and shifts published data are to demonstrate the existence of other kinds of regularities within similar spectra of different elements and their ionization stages. The emphasis is on the Stark parameter dependence on the upper level ionization potential and on the rest core charge for the lines from similar spectra. The found relations connecting Stark shift parameters with upper level ionization potential, rest core charge and electron temperature were used for a prediction of new Stark broadening data, thus avoiding much more complicated procedures.

SP08 - 202

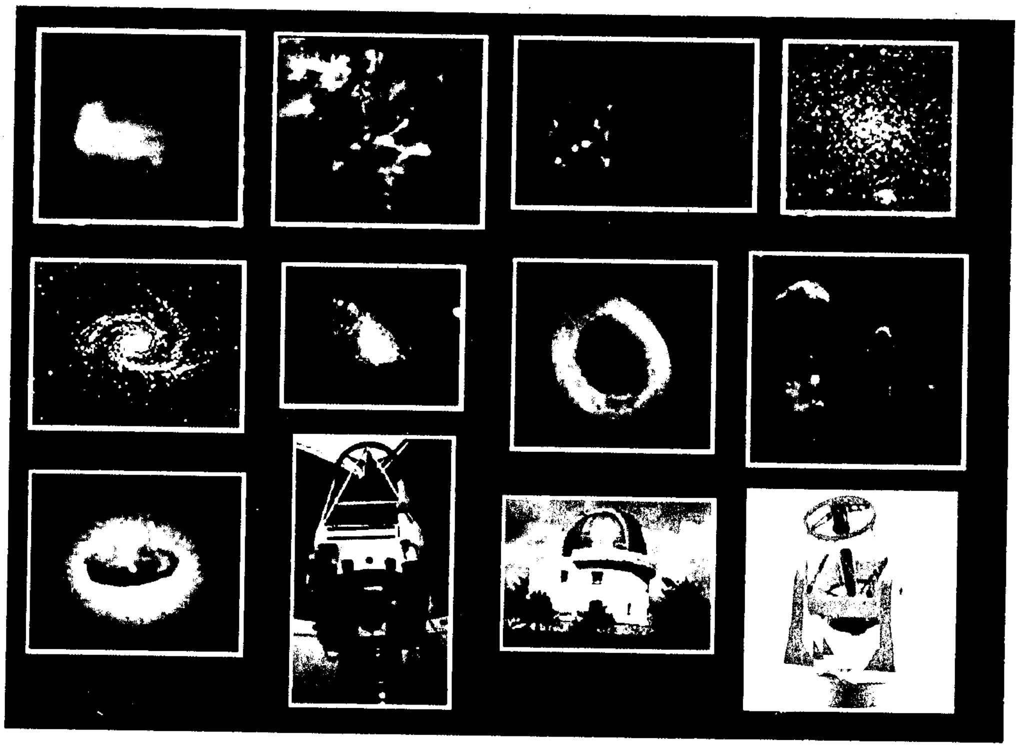
STARK WIDTHS IN THE F II 3S' – 3P' TRANSITION

A. SREĆKOVIĆ, S. BUKVIĆ, S. DJENIŽE, AND M. S. DIMITRIJEVIĆ*

Faculty of Physics, University of Belgrade, P. O. Box 368, Serbia
*Astronomical Observatory 11 160 Belgrade, Volgina 7, Serbia

Stark FWHM (full-width at half intensity maximum, W) of four singly ionised fluorine (F II) spectral lines (410.917 nm, 354.177 nm, 429.918 nm and 320.274 nm) in $2p^3 3s'$ - $2p^3(^2D^0)3p'$ transition have been measured in a linear, low-pressure, pulsed arc discharge created in SF_6 plasma at 30 400 – 33 600 K electron temperatures and at (2.75-2.80) 10^{23} m^{-3} electron densities. The measured Stark widths have been compared with our theoretical data obtained within the semiclassical perturbation formalism (SCPF).

5th Hellenic Astronomical Conference, organized by the Hellenic Astronomical Society
20 - 22 September 2001,Fodele Crete, Hellas



BOOK OF ABSTRACTS

Hosted by: Section of
Astrophysics and Space
Physics, Department of
Physics, University of Crete

Organized by:
the Hellenic
Astronomical Society

Title: Calendar of the Greek Orthodox Church

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ABSTRACT:
At the Orthodox Church Council in 1923 in Constantinoupolis a proposal concerning the reform of the calendar, elaborated by the Serbian astronomer Milutin Milancovic together with professor Maksim Trpkovic, was submitted, providing for a more exact calendar than the Gregorian one. Instead of three days in 4 centuries one should omit 7 days in 9 centuries or 0.0077 days per year. This means that only 2 years out of 9 ending the centuries, would be leap years. The rule is that those years whose ordinal number ends with two zeros are leap years only provided that the number of centuries they belong to, divided by 9, yields the remainder 2 or 6. For instance the year 2000, ending the 20th century, is a leap year since 20 divided by 9 equals to 2 plus the remainder 2.

Milancovic's proposal implies a much smaller difference, with respect to the true tropical year, than Gregorian calendar. Further improvements concerning the approaching to the duration of the tropical year are not necessary since that duration itself undergoes changes over longer periods.

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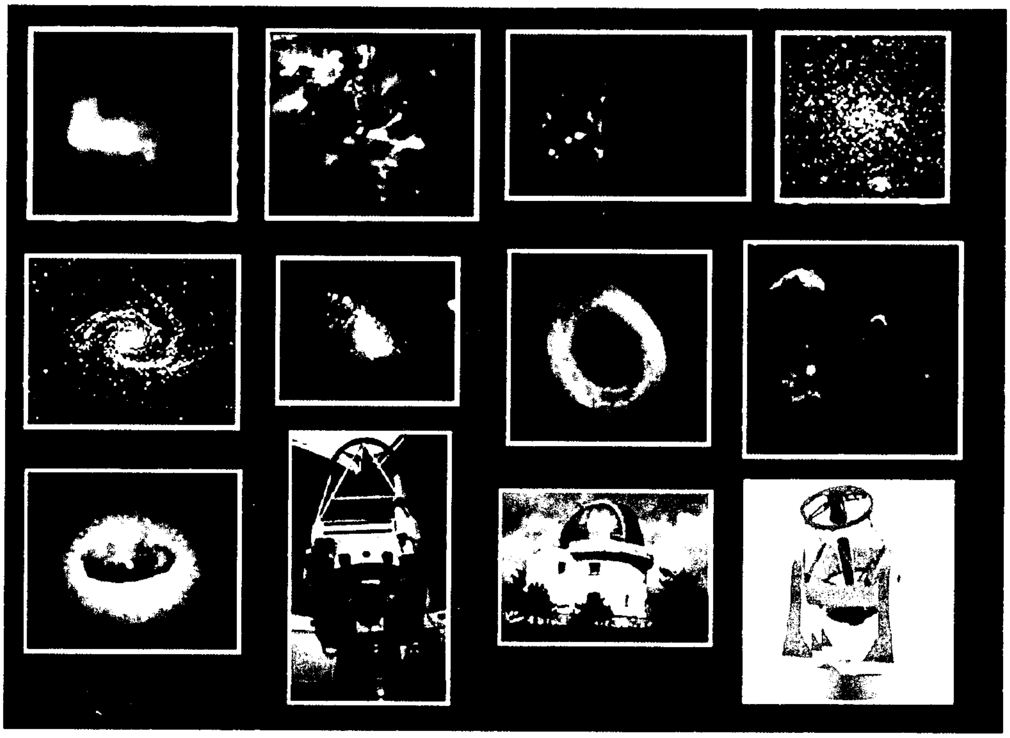

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Title: The Electron-impact broadening effect in Stellar Atmospheres: Rare Earth Elements.

Author(s): L. C. Popovic[1], M. S. Dimitrijevic[1], S. Simic[2] and N.Milovanovic[1]
Institute(s) : Belgrade Astronomical Observatory, Yugoslavia[1]
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ABSTRACT:
The influence of the Stark broadening mechanism on line shapes and equivalent widths in stellar atmosphere has been considered. The test of this influence has been done for Nd II, Eu II and Eu III lines. For calculations of the electron-impact widths we use the modified semi-empirical approach (MSE).

Hellenic Astronomical Society

Invited Lecture

DEVELOPMENT OF ASTRONOMY AMONG SERBS FROM THE BEGINNING OF XVIII CENTURY UNTIL THE FIRST WORLD WAR

Milan S. Dimitrijević

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DEVELOPMENT OF ASTRONOMY AMONG SERBS FROM THE BEGINNING OF XVIII CENTURY UNTIL THE FIRST WORLD WAR

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1. EIGHTEENTH CENTURY

In the eighteenth century, only Rudjer Bošković among Serbs worked as a scientist on astronomy. He investigated different astronomical problems, developed his theory on atoms and founded the Brera observatory in Milano. In the year 1739 he wrote: *De novo telescopii usu ad objectes coelestis determinanda.* He wrote works on optics and also on the construction and use of the optical instruments, telescopes, heliostats, on ocular adjusting, on meridian determination, on errors of meridian instrument etc.

Besides the theoretical work in the research field of astronomy, Rudjer Bošković also observed. So, he published results of his two observations of Mercury transit across the solar disc: *De Mercurii novissimo infra Solem transitu,* 1737 and *Osservazioni de ultimo passagio di Mercurio sotto il Sole*, 1753. He measured two degrees of the meridian circle between Rome and Rimini, together with Ch. Le Maire in order to determine more precisely the Earth's shape and the map of the Vatican state. Also, in 1736, Bošković wrote the book: *De maculis Solaribus* on solar spots and their observations. Later in 1777, he observed solar spots from France, and wrote on methods of observations and on his perceptions on the solar nature.

Comets also attracted his attention so that he observed them from 1744, and after that, in 1746, he wrote the article: *De cometis.* On the occasion of the comet of 1744, he also published a method for the determination of comet's orbit on the basis of his observations in three slightly distant positions.

In this period a Count from Bologna, Luigi [Aloysius] Ferdinandus Marsigli (1658-1730), performed astronomical observations from Serbian country. A soldier by profession, a scientist by voccation, an exceptional man with a universal spirit, he published the results of his investigations in Amsterdam in 1726 in the monumental work of six volumes: *Danubius Pannonico – Mysicus, observationibus geographicis, astronomicis, hydrographicis, historicis, physicis*. On the 35 pages in the second part of the first volume, he describes, with detailed drawings, results of his astronomical observations, performed in today Serbia (region Vojvodina) in June and July 1696. On the confluent of rivers Drava and Danube and in the Titel fortress, he determined, by using astronomical methods, the local geographical latitudes and the heights of the Sun on the meridian. He observed also Jupiter and his four satellites and sketched the Moon's appearance. Moreover, from the bridge on Crna Bara near Bačko Gradište he performed observations of Jupiter and his satellites and made drawings of the surface of the Moon. He observed again Jupiter and its satellites from Senta and in Žabalj he drew the map of the Moon (Jovanović, 1985). The work of Count Marsigli, a man of encyclopedical wideness, puts him among men of exceptional interest in the history of science of the eighteenth century in Serbian countries.

It is interesting also, that the great traveler, poet, theologian and at the end archimandrite Jovan Rajić (11. XI 1726 – 11. XII 1801) was teaching astronomy in the so called Latin school in Sremski Karlovci from 1749 up to 1768. The manuscript of his lectures is preserved (Janković, 1985). At the same time he was an observer, and his description of the observations of a comet of 1769 is also preserved. In Great Serbian orthodox grammar-school astronomy is taught according to Walch text-book of 1794 written in German. Elements of

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* Hel.A.S Invited Speaker

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astronomy are also included in the courses of mathematical geography and physics (Jovanović, 1990).

2. ENLIGHTENERS AND POPULARIZATORS

Other witnesses of interest to Astronomy are different translations and alterations of texts concerning this science. Besides, astronomical contents may be found in calendars, which start to be printed in Serbian in the second half of the eighteenth century. From 1765 up to the end of the XVIII century only a dozen of calendars have been printed, while in the middle of the XIX century a large number of different calendars is printed every year.

The scientific life in Serbian countries at the end of the eighteenth and the beginning of the nineteenth century is denoted by the "enlightener" spirit of Dositej Obradović. For him, the science was at first a mean to enlighten the people and to suppress the superstition. The most important among writers who followed such views of Dositej was Atanasije Stojković (1733-1832), doctor of philosophy and fellow of German scientific societies. He finished the so called Grammatical latin school in his native town Ruma and started to work as a teacher. He continued the studies of philosophy and law in Sopron, Szegedin and Pozhun. Also, he learnd physics and philosophy in Goettingen (Germany), where in 1799, he became a doctor of philosophy. The same year he returned to Serbia and wrote the first modern Serbian text-book on Physics, *Fisika* (Part I, 1801; Part II, 1802; Part III, 1803). He also published the books: *Kandor ili Otkrovenije egipetskih tajn* (Candor or the revelation of Egyptian secrets), 1800, which is written on the model of Voltair's *Candide, Aristid i Natalija* (Aristid and Natalie), 1801 and *Srpski sekretar* (Serbian secretary), 1802. In 1803 he was elected professor of physics at Kharkov University, where he arrived from Serbia in 1804 (Deretić, 1973). In Kharkov he was rector for two times (1807 and 1811) and he wrote his most important works (Milogradov-Turin, 2001a) as for example a book on meteorites: *O vozdushnykh kamnyakh i ikh proiskhozhdenii* (On air stones and their origin) 1807, and *Nachalnaya osnovaniya fizicheskoj astronomii* (Starting bases of physical astronomy), 1813. In honor of his scientific results concerning meteorites, Leonid Yakovlevich Kulik named a hill near the place of Tunguska event hill Stojkovich (Milogradov-Turin, 2001ab). In 1809 he was elected correspondent fellow of the Imperial Academy of Sciences in Sankt Peterburg (Milogradov-Turin, 2001a). He left Kharkov in 1813 and he spent his last years of life mainly in Sankt Peterburg.

3. SECOND HALF OF THE NINETEENTH CENTURY

In the second half of the nineteenth century a basis permitting to Astronomy to become a real science and to find a place in secondary schools and in Grand School is developed. In this period an Astronomical and Meteorological Observatory has been founded (1887), as well as the Chair for Astronomy and Meteorology. In this period the first scientific articles in today's sense are published, the first textbooks are appearing and the amateur astronomy starts to develop.

In 1849, Vuk Marinković (1807 - 1859) becomes by invitation professor of Lyceum. He was the first of physics teachers at Lyceum and he taught physics from 1849 up to 1859 and wrote his textbook: *Načela fizike* (Principles of Physics), published in 1851, and containing astronomical subjects. He taught astronomy probably from 1849 together with physical geography.

It is interesting that one priest, Djordje (Gavrilo) Popović (1811 Baja – 1871 Beograd) was also a popularizator of astronomy. In 1850 he published the book: *Astronomija ili nauka o zvezdama* (Astronomy or the science about stars).

During the considered period Amateur Astronomy appears among Serbs. Jovan (Julijan) Čokor (21.01/2.02 1810 Baja – 1/13.06 1871 Sremski Karlovci) can be considered as one of the first amateur astronomers in serbian countries (Janković, 1955). He made a small observatory in Sremski Karlovci and he also produced sun-dials. Among the Amateur Astronomers were also doctor Djordje Maksimović (1838 – 1881), officer and diplomat Petar

Manojlović Selim, the writer of the first serbian science fiction novel: *Jedna ugašena zvezda* (Beograd, 1902) Lazar Komarčić, Sreten Hadžić and others.

Jelenko M. Mihajlović (January 11, 1869 Vrbica near Knjaževac – October 30, 1956, Belgrade) is founder of modern Serbian seismology, and he published a large number of works related to geological and particularly seismological features of our country. Within the period 1893 - 1906 he was the coworker of Milan Nedeljković, the founder of Belgrade Astronomical and Meteorological Observatory (Banjac, 1999). He was also the author of the numerous textbooks, popular scientific books and articles, concerning spectroscopy, photometry and photography in astronomy.

Cousins Ivan and Ilija Milošević left also a trace in the history of Serbian astronomy of the nineteenth century. They are descendents of Boka Kotorska and they were both born in Venice – Ivan in 1850 and Ilija in 1848 (Protić-Benišek, 2002).

Ivan, devoted himself to mathematics and he left several astronomical works. The most known is: *O najskorijem prehodu Danice preko Sunčevog kola* (On the approaching Venus transit across the Solar disc), concerning the transit of Venus of 1874. This work is important for the history of astronomy since it is the first work on the Venus transit across the Solar disc on Serbian language.

Ilija Milošević, the son of Filip Milošević, sailor and merchant from Dobrota near Kotor, was a professor of astronomy in the Naval institute in Venice and during 1879-1902 vice director and director of the "Collegio Romano" Observatory. He worked on the theory of asteroid orbits and their perturbations. He drew Particular attention to the determination of the ephemerides' corrections for the transit of Venus across the solar disc on 8 December 1882 and the transit of Mercury on 6 May 1878. He discovered two asteroids, 303 Josephina and 306 Unitas (Protić-Benišek, 2002).

For the history of astronomy of this period important are also the articles *Soko-Banja, prvi meteorit u Srbiji* (Soko-Banja, the first meteorite in Serbia) by Josif Pančić (*Glasnik Srpskog učenog društva*, 1880, XLVIII) and *Jelički meteorit* (The meteorite of Jelica) by Jovan Žujović (*Geološki anali*, 1890).

4. STEVAN P. BOŠKOVIĆ AND ASTROGEODETICAL DETERMINATIONS IN THE KINGDOM OF SERBIA

Stevan P. Bošković was born in Zaječar in 1868. He finished the Military Academy in Belgrade in 1889 and in 1892, as a state scholarship holder, he was sent to Russia to study geodesy and astronomy. He was the first officer of Serbian army sent to specialize in advanced geodesy and positional astronomy, since the military authorities noticed the importance of the establishment of the state trigonometric network as the basis for an exact triangulation of Serbia (Dačić and Cvetković, 2002). After finishing the theoretical training in 1897, Bošković came to Pulkovo Observatory, where he learned fundamental astronomy and astrometry. In Pulkovo, Bošković calculated and prepared for the territory of Serbia ephemerides for stellar pairs for determination of time with the Tsinger method and for the determination of latitude by the Pevcov method, as well as Polar star ephemerides for the determination of the azimuth. He also prepared in Pulkovo the project of triangulation of Serbia and the program of astronomical observations. After his return from Russia in 1899 he became professor of geodesy at the Military Academy.

During his studies in Pulkovo Bošković suspected that the reason for geodetic and consequently cartografic, mainly longitudinal disagreement among countries in Panonical and Pontical pools, is probably the deviation of vertical from his normal position toward the ideally curved surface of Earth's geoid. He planned geodetical and astronomical projects in order to check his assumptions. He choosed for this a series of points on the highest mountains, and another series of points in river valleys, counting that in such a way he will examine and discover suspected attractive influences on the normal direction of the Earth's gravitational force intensity, and consequently the deviation of the vertical.

The first determinations on the first – north point of Paraćin's basis and on the highest top – Šiljak of the Rtanj mountain in 1900 gave very good results. Projects on trigonometrical triangulation, on topographical measurements for an 1:25000 map, on topographical measurements of regions liberated during Balkan wars 1912-1913 and the First World War, prevented him of working out of the huge astronomical material which is however preserved. It was transferred by the Serbian army to Krf , after in Saloniki, and after the victory, from Saloniki to Belgrade.

Academician and General Stevan P. Bošković gave great contribution to development of Serbian geodesy, topography and cartography. Also, he is one of the great names of serbian astronomy.

6. MILAN NEDELJKOVIĆ AND THE FOUNDATION OF THE CHAIR FOR ASTRONOMY AND METEOROLOGY

One of the most important personalities within the considered period is certainly the founder of the Chair for Astronomy and Meteorology and of the Belgrade Astronomical and Meteorological Observatory Milan Nedeljković (Belgrade 27. Sept. 1857 - Belgrade 27 Dec. 1950). As a junior lecturer of physics and mathematics at the Grand School (Belgrade University) he applied on August 16, 1878, at the Ministry of Education for continuing abroad his studies, specifically in physics and astronomy and besides analytical and rational mechanics and mathematics. Minister Bošković asked for the opinion of the rector, which arrived on June 12, 1879. According to this opinion the plan of Nedeljković's studies was as follows: 1) The first two years to attend lectures in infinitesimal calculus, probability calculus, mathematical physics, meteorology, rational and analytical mechanics, higher geodesy and astronomy; 2) The third year to dedicate to practical training at the Paris Observatory and to attend special lectures in astronomy and meteorology, mainly those treating the theory and the use of the astronomical and meteorological instruments; 3) The first half of the fourth year was to be spend in London and the second in traveling, visiting thereby the most important astronomical and meteorological establishments. This opinion was signed by Josif Pančić, Kosta Alković, Sima Lozanić, Ljubomir Klerić, Dimitrije Nešić and Dimitrije Stojanović (Janković, 1989). By this opinion Nedeljković was directed towards the astronomical and meteorological studies and on that account he, as a state scholarship holder, was sent to France.

The Grand School Organization Law, passed in 1863, does not refer to astronomy. Astronomy was introduced in 1880 by the Modifications and Supplements of the same Law as a separate subject at the Natural-Mathematical Department of the Philosophical Faculty of the Grand School, the lectures on which were to be attended also by the engineering students. This decision came into force only in 1884 when Milan Nedeljković was back from his studies in France.

On returning from his studies Milan Nedeljković was appointed junior lecturer of astronomy and meteorology, being at the same time entrusted with the Chair for Astronomy and Meteorology of the Grand School, the post he held forty years, until his retirement in 1924. The only break took place between 5th of July 1899 and 31st of October 1900, when he was sent into retirement for political reasons and the Chair for Astronomy and Meteorology has been entrusted to Djordje Stanojević.

7. DJORDJE STANOJEVIĆ THE FIRST SERBIAN ASTROPHYSICIST

Djordje Stanojević (Negotin, 7 April 1858 - Paris 24 Dec. 1921), the first Serbian astrophysicist, the second director of the Belgrade astronomical and meteorological observatory and later rector of Belgrade University, a great popularizator of astronomy and science in general, was the driving force in the introduction of electrical light in Belgrade, Užice, Čačak, Leskovac... He was the builder of the first hydro-electric power station in Serbia, a pioneer of industry of refrigerating appliances, the initiator of setting up a committee for cooling problems and of forming an international organization for cooling techniques in Paris in 1903. He was also the pioneer of the color photography in Serbia.

He finished the elementary school and lower secondary school in his native town Negotin, where today his memorial room is in exhibition. As a grant holder of the Ministry of Military affairs he was from 1883 up to 1887 on study, specialization and work on the most known astronomical and meteorological institutions in Europe in: Berlin (University), Potsdam (Astrophysical observatory), Hamburg (meteorological institute), Paris (Sorbonne), Meudon (Paris observatory for physical astronomy), Greenwich, London and Pulkovo. During this period Stanojević turns to astrophysics and chooses Solar physics as his research field.

In Meudon he works with the founder of this Observatory, the famous astrophysicist Jansen and there he begins the serious scientific work in solar physics and spectroscopy. In 1885 he publishes his first real scientific work: *Analyse spectrale des elements de l'atmosphere terestre* in the journal Communication *a l' Academie des Sciences de Paris*. In the next year, 1886, in this well known scientific journal he publishes the work: *Sur l'origine du resau photospherique Solaire* and *Sur le spectre d'absorption de l'Oxygene* (Trifunović, Dimić, 1976). In 1887 he publishes the scientific work: *Sur la photographie directe de l'etat barometrique de l'atmosphere Solaire*. These astrophysical scientific works, published in editions of the Paris academy of sciences, are the first real scientific works in the modern sense in astrophysics among Serbs.

At the end of his stay in Paris, in August of 1887, he participated as a representative of Paris observatory in the expedition for the observation of the total solar eclipse of 19 August 1887 in Russia (Petrovsk) and published his report (*L'eclipse totale du Soleil du 19 aout 1887, observe en Russie (Petrowsk)*) in the journal of Paris academy. Weather has not been favorable and only 20-25 seconds of observations were successful.

After his return in Serbia in 1887, he became a professor of Physics and Mechanics of the Military academy. He was invited by the Paris observatory to take part in French expedition for investigations of the Sun in Sahara, where he stayed for three months (1891 - 1892). In 1893, after the retirement of Kosta Alković, he became the professor of Experimental physics in Grand School, where he became the director of the Physical institute. From 1900 up to 1913 he was dean of the Philosophical faculty and from 1913 up to 1921 rector of the Belgrade University.

Between 5th of July 1899 and 31st of October 1900 Djordje Stanojević is director of Belgrade astronomical and meteorological observatory and on the head of the Chair for astronomy and meteorology in the Grand School.

His scientific results were so above the scientific level in Serbia that Serbian royal academy rejected the publication of his article on solar physics. Disappointed he practically leaves the scientific work in astrophysics. In editions of the Paris academy of sciences he publishes after that only a review: *L'etat actuel de la photographie du Soleil*, in 1889.

After this he works in physics and on practical problems of electrification and industrialization of Serbia. He performs electrification of Belgrade, Užice, Leskovac, Čačak, Zaječar... He takes part in the construction of the first hydro - electric power station in Serbia near Užice. In Grand School he organises a service for the repairment of electromotors. He introduces color photography in Serbia and publishes in 1901 the first book with such photos: *Srbija u slikama (fotografski snimci)* (Serbia in pictures (photographies)). He continues on serious scientific work in physics, and after a break of nine years his scientific articles appear again in *Communication a l' Academie des Sciences de Paris*, but now on experimental physics (Trifunović, Dimić, 1976).

8. FOUNDATION OF ASTRONOMICAL AND METEOROLOGICAL OBSERVATORY

The principal astronomical institution in Serbia is the Belgrade Astronomical Observatory, one of the oldest scientific organizations and the only autonomous astronomical institute in Yugoslavia. Its past development forms an important part of the history of science and culture in these regions. The decree of its founding conjointly with the Meteorological Observatory was signed on 20 March (7 April) 1887 by the Minister of Education and Church Affaires of Kingdom of Serbia Milan Kujundžić Aberdar on the initiative of Milan Nedeljković. He was appointed first director of the newly founded Observatory.

On the 1st of May of 1871 Nedeljković started his activity at the provisory Observatory in the rented Geizler family's house. Here, the Observatory was operating until the 1st of May of 1891, when it was moved into its own building constructed meanwhile - the one in which at present is Meteorological Observatory in the Karadjordje Park. In the minor museum section of this building there is, since the celebration of the Observatory's centenary in 1987, a room dedicated to the origins of astronomical science in Serbia and Montenegro.

Nedeljković was at the head of the Observatory from 26 March (7 April) 1887 until the 30st of January 1924. A break took place only between 5th of July 1899 and 31st of October 1900, when he was sent into retirement for political reasons.

Apart from its importance for astronomy and meteorology, the newly built Observatory, headed by Nedeljković, was a cradle of the seismic and geomagnetic researches in Serbia. In the course of its history the Belgrade Astronomical Observatory grew to an institution of great importance in the history of science and culture of the Serbian people. Linked to this institution are the names of the famous personalities in the history of science, who contributed to the Observatory and the scientific achievements of Serbian astronomers in general, having earned esteem in the international scientific community. Young people in our country have a good perspective, in engaging in this beautiful and challenging science, in an ambiance enabling them to achieve results of the highest value.

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INVITED LECTURES

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PROGRAM AND ABSTRACTS, EDS. MILAN S. DIMITRIJEVIĆ, MILCHO TSVETKOV,
LUKA Č. POPOVIĆ, VALERI GOLEV, ASTRONOMICAL OBSERVATORY, BELGRADE, 2008

Invited lecture

FOUNDATION OF PHYSICS ON TOPOLOGICAL SPACES

DUŠAN ĆIRIĆ

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The aim of this paper is to introduce the notion of self-motion of every topological space, to prove some properties of such defined notion and to build a physics on every topological space. Idea is that every topological space has his own physics.

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Invited lecture

MASSIVE CLUSTER CANDIDATES IN M33: A MILTITELESCOPE VIEW

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The study of the massive star-cluster systems in the Local Group provides important information about the integral properties of their stellar population and overall structural and chemical evolution. Since for these studies the completeness of the sample of detected clusters is critical, many extensive surveys have been recently initiated both from space and ground. The M33 galaxy is the only late-type spiral in the Local Group, and thus of particular interest. The most comprehensive catalogues available to date of confirmed genuine star-clusters in M33 are presented by Park & Lee (2007) and Sarajedini & Mancone (2007). The catalogues incorporate several recent studies based on HST/WFPC2 (Chandar et al. 2001) and HST/ACS (Bedin et al., 2005, Sarajedini et al., 2007) archive images. However, the areas of M33 covered by the HST-based surveys are much smaller than the entire area of the galaxy. Thus, a significant number of star-cluster candidates identified in early photometric surveys are omitted in the HST-based catalogues. The present work is focused on 46 star-cluster candidates located in the central 10′x10′ part of the M33 galaxy, most recently studied by Kunchev & Kaltcheva (1997). None of these candidates is included in the recent HST-based catalogues. We utilize CFHT and KPNO Megacams multicolor photometry, HST/ACS and WFPC2 archive images and 2MASS data to cast light on the nature of these objects.

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Invited lecture

THE PROCESSES OF (n-n')-MIXING IN ATOM-RYDBERG ATOM COLLISIONS IN STELLAR ATMOSPHERES

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In several previous papers it has already been shown that chemi-ionization processes in slow atom-Rydberg atom collisions play a very important role in weakly ionized plasmas, since they successfully competee with the known electron-atom ionization processes. However, recently appeared indications that (n - n')-mixing processes in atom-Rydberg atom collisions, due to their significant efficiency, also play significant role for weakly ionized plasma kinetics, because of their influence to excited states populations. The main aim of this work is to show that they have to be included in models of weakly ionized layers of stellar atmospheres, which is illustrated by examples of the photosphere and lower chromosphere of Sun (hydrogen case), and by photospheres of some DB white dwarfs.

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Invited lecture

CEPHEID COMPLEXES OF THE MILKY WAY

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A method for identification of Cepheid complexes in Milky Way is applied. Based on the search algorithm and the data of Cepheids (Berdnikov et al. 2000) were found 18 Cepheid complexes of Milky Way with space (3D) density $ 5.0 \sigma $ density peak with an excess of about ten objects. The data for OB, WR stars, open clusters, stellar associations, and HII regions were used too. These objects have a hierarchical structure in space. The results show the existence of a correlation between OB associations, HII regions, and WR stars that trace the regions of massive star formation. Probably stellar associations, HII regions and open clusters from nearby sites of star formation form regions of 1kpc centered in the Cepheid complexes. We consider this fact as a ground for identification of 18 Cepheid complexes in the Milky Way.

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Invited lecture

ON THE MODELLING OF ASTROPHYSICAL SPECTRA USING PHOENIX

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We will review recent developments in general stellar atmosphere code Phoenix. Comparison between modeled spectra for variety of astrophysical objects from cool dwarfs, through stars with the winds up to supernovae and AGN's will be made. Also we will explore some of more 'exotic' problems such as Lithium isotopic ratio, chemi-ionization/recombination processes in red and white dwarfs, Stark broadening and its influence on line shapes.

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Invited lecture

VARIATIONS IN AN ACCRETION DISK EMISSIVITY – REPERCUSSIONS TO THE Fe Kα LINE PROFILE

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The observed profiles of the Fe Kα line in case of some Active Galactic Nuclei (AGN) show certain irregularities which are not predicted by standard model of accretion disk. In this paper we propose a modification of disk emissivity law in order to explain the observed profiles. The disk emission was analyzed using the ray-tracing method in Kerr metric, assuming a modification of power-law emissivity which allows us to include perturbations in disk emission due to photoionization. When the emissivity law is modified in such way, we find that the corresponding variations in disk emission can explain the observed Fe Kα line profiles if the line is emitted from the innermost part of the accretion disk.

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Invited lecture

CHEMI-IONIZATION – EXPERIMENTS, THEORIES, GEOCOSMICAL PERSPECTIVES

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Elementary chemi-ionization processes with optically excited atoms participation may be considered as a prototype of the elementary process of the radiation energy transformation into electrical one. These reactions involving highly excited Rydberg atoms (RA) in geocosmical plasmas traditionally attract researcher's attention (see, for example Mihajlov et al., 2003).

The systematic studies – experiment (Devdariani et al., 1978) and theory (Janev and Mihajlov, 1980; Duman and Shamatov, 1980) of the RA chemi-ionization was started relatively recently. The theory was later complicated taking into account effect of the Rydberg electron (RE) stochastic instability during one collision (Bezuglov et al., 1997).

Received results show that the resonant mechanism of the chemi-ionization (Janev and Mihajlov, 1980) at first suggested in (Smirnov and Mihajlov, 1971) and stochastic approach (Bezuglov et al., 1997) are adequate in a wide range of the RA principal quantum numbers and temperatures (Klyucharev et al., 2007).

Our attention will be paid to the ionization via RA+A and RA+B collisions – symmetrical and non-symmetrical cases:

$$RA + A \rightarrow (RA_2^*) \rightarrow A_2^+ + e$$
$$A_2^+ + e \rightarrow A^+ + A + e,$$
$$RA + B \rightarrow (RAB^*) \rightarrow AB^+ + e$$
$$AB^+ + e \rightarrow A^+ + B + e$$

Obtained rate coefficients are recommended for geocosmical plasma's models and possible further investigations and technological applications. We assume that the conditions of the cold collisions will favor the observation of the diffusion processes in collisional reactions during one collision.

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Invited lecture

SOME ASPECTS OF ASTEROID MASS DETERMINATION

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There is a great variety of astronomical objects in the Universe. Each of these classes of objects follows a certain distribution function in size, luminosity or mass. Most individual mass distributions approximately follow a power law of the form $f(M) \propto M^{-2}$. A notable exception are planets and small bodies which seem to obey a flatter distribution. In spite of the rapidly growing number of newly detected extrasolar planets, our knowledge of the mass function of planetary and small bodies relay entirely on the our Solar System. If is there a "universal" mass distribution for astronomical objects on all scales, it will be very important to know mass distribution of small solar system bodies. Having in mind mentioned reasons we will present methods for asteroid mass determination as well as some of most interesting results.

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Invited lecture

MILANKOVIĆ'S "THE END OF THE WORLD"

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The Milanković's numerical trajectory of secular changes of pole's rotation has shown that its latest positions in positive infinity can be observed on the North Pole of the Siberian plate. Milanković with his discovers "the end of the world" or total end of activity in astenosphere. In other words, he discovers plate tectonics of pole's (convergence, divergence, and transform movement), earthquakes, subduction zones, sea floor spreading, etc.

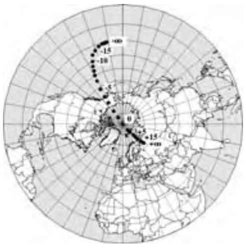
This is not just the end of the atmosphere existence, water or life on the planet, but also a geodynamic, co-mechanic and co-climatological climax. This is the beginning of the ice ages. The pole of rotation, by Milanković, reaches $\lambda = +49^o\ 34'$; $\varphi = +65^o\ 16'$ for the Northern Hemisphere or $\lambda = -130^o\ 26'$; $\varphi = -65^o\ 16'$ for Southern Hemisphere.

Based on this data and according to the pole spreading of lithosphere, it is possible to recognize future climatic zones under geographical latitudes and longitudes. These are also known as the green zones, the most endangered continental places. The entire Europe and the parts of Asia will be under ice. Studying the continent of North America we can observe only a part of Canada is under ice (up to 60 of geographical longitude). This will happen due to continuous Atlantic sea floor spreading, and also due to the counterclockwise rotation of the North American plate. This will cause the continents to move away from the North Pole.

The problem of some time units and numerical secular positions, Milanković calculated and graphically presented, still stands as one of the greatest planetary enigmas. Their close picture is available through geophysical, geodetic, and mathematical methods, satellites, stations on the Earth's surface and also through practicing new technology.

The mentioned "end of the world" does not present the end of the Earth's cosmic phase. It does not correspond to astronomical age determinants and further planetary deviation. Milanković has experienced and mathematically presented cinematic planetary model of continents. He further included the water areas, atmosphere, and living beings.

The Milanković's "end of the world" is just an end of the pole's tectonics, critical temperatures and fluidly fall in the atmosphere. Also, it is the ending of the seismic phase, rift genesis, subdaction, and radioactivity. However, all together will not have any further consequences on the other structures, especially not on the Earth's nucleus. The Milanković's end of the world resembles the minimization of mechanical secular changes of the pole rotation. The Earth's rotation itself stays unchanged or barely changed.



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Invited lecture

ASTRONOMICAL VIRTUAL OBSERVATORY. BULGARIAN VIRTUAL OBSERVATORY - PLACE AND ROLE.

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Basic principles of the Virtual observatory are described. Steps of establishment of Bulgarian virtual observatory departments are marked – Bulgarian Solar Virtual observatory and Galaxian Virtual observatory. A brief description of the data, included in the Bulgarian Virtual observatory Date Base are presented.

Sun: The data from the solar coronagraph in the National astronomical observatory “Rozhen” and in the People’s observatories around the country will be included. The basic instruments in the solar tower at NAO – Rozhen, which produce the data are the Lyot-coronagraph (150/2250) with Hα filter (1.8Å) and the solar refractor (150/1600).

Galaxies: Here will be presented the row and/or calibrated data from the 2_m RCC telescope of the National astronomical observatory “Rozhen”, 60_cm telescope of the Belogradchick observatory and some data from other observatories. At the time being we have thousands of faint galaxies in voids, several tents of Box/Peanut galaxies and Active Galaxies Nuclei, quasars and BL Lac objects, gravitational lenses, ca. 30 open clusters and few planetary nebulae.

In the near future all the data will be distributed by means of MySQL or PostgreSQL databases.

Invited lecture

STELLAR POPULATIONS IN ACTIVE GALAXIES

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The activity of galaxies is linked to the growth of the black hole and to the building-up of the stellar population. By studying this stellar population, its history and kinematics, we get insight into the past evolution of the presently active nuclei. We will present the different diagnostics tools allowing to understand this history.

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Invited lecture

GEOPHYSICAL CONTRIBUTIONS IN PRECESSION-NUTATION

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Recently we found, from the analysis of Very Long-Baseline Interferometry (VLBI) observations and using resonant effects in several forced nutation terms (Vondrák, Ron 2006a, 2006b, 2007), small quasi-periodic fluctuations of the period of retrograde Free Core Nutation (FCN), ranging from 429.8 to 430.8 days. In our preceding studies we were also able to demonstrate that the atmospheric and oceanic excitations are capable of exciting nutation near the resonance of FCN; both amplitude and phase of the geophysically excited pole are consistent with the values observed by VLBI, in the interval of tens of years. The geophysical excitations are now numerically integrated, using Brzezinski's broadband Liouville equations (Brzezinski 1994) in order to estimate the influence of the atmosphere and oceans on precession and nutation. It is then removed from the celestial pole offsets, observed by VLBI. The remaining part is then used to derive the period and quality factor of FCN in running intervals, and to study the temporal stability of these important Earth parameters.

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SHORT TALKS

Short talk

ON THE DISTANCE OF KR AURIGAE

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We estimated the distance of the cataclysmic variable KR Aur using the photometric measurements of the minimum brightness in BVRI bands and different kinds of empirical dependences on the P_{orb}, masses, absolute magnitudes and color-indexes of the components of the system. We used also 2MASS measurement of the K-magnitude received close to faintest state. The evaluation of the distance and other parameters of the KR Aur were compared with other ones of the similar VY Scl type variables.

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Short talk

INVESTIGATIONS ON BELGRADE OBSERVATORY OF THE INFLUENCE OF COLLISIONAL PROCESSES ON ASTROPHYSICAL PLASMA SPECTRA IN 2006-2008

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The brief review of activities on the project "Influence of collisional processes on the astrophysical plasma spectra", from 1st January 2006 up to 1st May 2008 is given, in order to inform on our recent activities in this research field, with results of interest for the investigation, modeling and diagnostic of astrophysical, but also laboratory and industrial plasmas. Here is given our bibliography for the considered period in order to show possible directions for collaboration.

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LUKA Č. POPOVIĆ, VALERI GOLEV, ASTRONOMICAL OBSERVATORY, BELGRADE, 2008

Short talk

ON THE REGULARITIES OF STARK BROADENING PARAMETERS WITHIN SPECTRAL SERIES: Ar I LINES

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The Stark broadening parameters (the width and shift) of six Ar I spectral lines: 522.1, 549.6, 518.6, 560.7, 603.2 and 696.5 nm, corresponding to the transitions $3p^5nd \rightarrow 3p^54p$ for n = 7-5 and $4p' \rightarrow 4s$ have been calculated within the semi-classical perturbation approach. The considered lines are in the optical part of the spectrum and are particularly of interest for the research of surface wave discharges.

With the development of space-born spectroscopy, the importance of atomic data, including the Stark broadening parameters, for trace elements like argon, increases. For example argon is found in CVn binary σ^2 Coronae Borealis, and "Chandra's" X-ray spectra of young supernovas 1998S and 2003bg revealed argon over-abundance. Recently, argon lines are observed in the optical spectrum of the Be star Hen 2-90. Consequently, Stark line broadening parameters for neutral and ionized argon are of interest for the modelling and investigation of astrophysical plasmas. We note here, that lines within the optical spectral range are particularly significant.

In this paper, results of the determination of Stark broadening parameters within the semiclassical perturbation method (Sahal-Bréchot, 1969a,b) for four visible argon lines (737.2, 603.2, 549.6 and 522.1 nm within the spectral series $3p^54p\ {}^2[5/2]_3{}^3D_3$- $3p^5nd\ {}^2[7/2]_4{}^3F_4^\circ$ are presented, and used for the investigation of regularities and systematic trends.

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Short talk

KINEMATICS OF THE POST-ERUPTIVE PHASE OF AN ERUPTIVE PROMINENCE ON 8 MAY 1979

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The kinematic pattern of the post-eruptive phase of the quiescent prominence which erupted on 8 May 1979 was studied. The eruption of the helically-twisted polar prominence originated in the southern leg of the huge magnetic system (HMS) that later produce a coronal mass ejection (CME). The kinematic evolution of the post-eruptive process was estimated by height-time profiles of the heights of the two main flux ropes (FRs) composing the body of eruptive prominence (EP) and horizontal expansion between the main FRs feet. The inflow velocity of the prominence plasma back to the chromosphere increased with constant acceleration of 76 m/s^2 and it reached a value up to 200 km/s. The horizontal expansion between the main FRs feet of the EP increased with an average constant velocity of 12 km/s in first order approximation, but in fact it had changed non-linearly. The obtained results were discussed as indicative ones for the kinematics and evolution of the magnetic field at the bottom of the erupting HMS.

Short talk

LINE SHAPE VARIABILITY OF NGC 4151

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We study the broad line shape variability of active galaxy NGC 4151 in a 11-years period, from 1996 until 2006 (Shapovalova et al. 2008). We found that the shapes of the broad emission lines are very complex and that they were changing in the observed period, indicating that the structure of the Broad Line Region (BLR) is changing. To explain such line shape variability we assume an outflow in the BLR.

Short talk

H-APLHA BRIGHTNESS EVOLUTION DURING THE ERUPTION OF PROMINENCE OF 7 MAY 1979 AND 8 JUNE 1980.

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We study H-aplha brightness during the evolution of the eruptive prominences (EPs), observed in H-alpha, on 7 May 1979 and 8 June 1980. Variations in H-alpha brightness in different parts of prominence body with respect to the prominence destabilization is examinated .

The mean values of relative H-alpha brightness of EPs bodies in arbitrary units are used to probe the pre-eruption state of the prominences.

H-alpha brightness evolution of two prominences with respect to low atmospheric magnetic reconnection processes that might be responsible for their destabilization and acceleration is considered

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Short talk

STELLAR POPULATIONS IN DWARF ELLIPTICAL GALAXIES

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The dwarf elliptical galaxies are the key for answering many questions of the modern cosmology. According to the prediction of the most popular cosmological theory - λCMD, they should be the most abundant type of galaxies (actually the predicted number exceed the observed number of dEs); they should contain big quantities of dark matter (M/L > 100Msun) ; they should be the first galaxies to form and those containing the oldest and most metal poor stars (not observed); they are valuable to study the effects of the environment (giving constraints on n-body simulations)...

All of this questions can be answered if we have knowledge about their stellar population and dynamics. Thanks to the new models, new tools of spectrum analyzing and new high quality observations we are starting to understand better this small galaxies.

We will present results for 15 dEs, observed with VLT (FORS1 and FORS2), analyzed with Pegase-HR models using full-spectrum fitting. Our conclusion is that this galaxies are more metal rich and younger then preciously thought, which already solved some puzzles (like CaT overabundance in the dEs).

Short talk

THE ROLE OF OPTICAL Fe II ^{4}F, ^{6}S AND ^{4}G GROUP OF LINES IN AGN SPECTRA

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In order to investigate optical Fe II λλ4450-5350 Å lines, which extreme emission can not be explained by standard photoionization model, we separate them in three groups by lower term of transition: ^{4}F, ^{6}S and ^{4}G. We examine the relations between those Fe II groups of lines and their correlations with other lines in AGN spectra.

Short talk[*]

ASTRONOMICAL SOCIETY "MAGELLANIC CLOUD"

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Astronomical society ***Magellanic cloud*** is founded in May 16. 2001. and it is sited in the town of Prokuplje, the South Serbia. It is established by A. Simonović, A. Valjarević, then students of geography at the University of Kosovska Mitrovica, Ž. Mijajlović professor of mathematics, S. Šegan, professor of astronomy, both at the University of Belgrade and D. Ćirić, professor of mathematics at the University of Niš. In this article we present the activities of the society in the popularization of astronomy and mathematics in Prokuplje and vicinity. Also, it is explained the role of the Society in rising the Astronomical station of the Astronomical observatory in Belgrade at the mountain Vidojevica nearby Prokuplje.

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[*] Last minute change to Poster.

Short talk

ASTROCLIMATIC CONDITIONS AT THE MOUNTAIN VIDOJEVICA

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Here are presented the main climate properties and weather conditions of Toplica, the region in the South Serbia. The particular emphasis is given to the astroclimate characteristics in the surrounding of the mountain Vidojevica nearby the town of Prokuplje. As it is known, there is situated the new astronomical station of the Astronomical Observatory in Belgrade, so astroclimate conditions may have important function in planning astronomical projects and observations. This article is based on various data, some of them collected since 1900. The data include the temperature, rainfall, insolation, relative humidity, cloudiness and number of days with clear sky. Both, macroclimate and microclimate characteristics are considered.

Short talk

METAPHYSICAL IDEAS IN PHYSICAL AND ASTRONOMICAL THEORIES

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Some philosophical ideas of interest to both physicists and astronomers are presented.

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LUKA Č. POPOVIĆ, VALERI GOLEV, ASTRONOMICAL OBSERVATORY, BELGRADE, 2008

Short talk

TECHNIQUE FOR TRACKING AND VISUALIZATION OF MOTION IN SEQUENCE OF IMAGES OF THE SOLAR CORONA

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The material represents specialized methodology for tracking and visualization the motion in sequence of pictures of the solar corona. The performance includes:

- Preliminary processing of each frame: initial analysis and elimination to atmospheric scattering of the light, image improvement using Gaussian filtering and a sharpen filtering for emphasizing of the contours;
- Processing to the series: clipping the area from the currently processed frame, alignment the clipping area with the same area in the initial frame, forming an image from the maximal brightness for each pixel of each picture of the sequence, calculation the –time-spatial gradient, determining the direction of gradient changes and visualization of the motion by transfer to saturation and colour hue for each pixel.

This technique is used for development of a special computer program working with pictures in FITS and JPG graphic formats.

The results from application the technique on the image sequences from the solar coronagraph of NAO Rozhen are showed.

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Short talk

SPECTROSCOPICAL INVESTIGATIONS OF EXTRAGALACTIC OBJECTS AT ASTRONOMICAL OBSERVATORY
(PERIOD 2006 – 2008)

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Here we will give an overview of the activity on the project (P 146002) “Astrophysical spectroscopy of extragalactic objects” financed by Ministry of Science of Serbia. The scientific activity can be divided into three subjects: (i) Investigation of Active Galactic Nuclei; (ii) Gravitational micro-lensing effect in spectra of quasars and (iii) Gamma-ray bursts. Besides of scientific work the participants of the project were involved in other activities as organizing international conferences, observations at other observatories, popularization of astronomy, etc. One of the significant results in mentioned period is development of international collaboration and accession to the observational facilities located at other observatories.

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Short talk

FUNDAMENTAL PLANE FOR DWARF AND NORMAL SPIRAL GALAXIES

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The existence of the fundamental plane of spiral galaxies is confirmed, which can be represented in observable terms by the absolute magnitude, the linear size of galactic disk and the rotation velocity. Applying the same formalism as for ellipticals: the virial theorem and an assumed homology (in both structure and kinematics) lead to a tigh three-parameter relation between the galaxy scaling parameters mentioned above. This fundamental plane is tested at several optical bands, and can reduce the residual of the Tully-Fisher relations by approximately 50%. A sample of dwarf spiral galaxies is tested for obeying the fundamental plane relation similar to that for spirals. It seems that the dwarf spirals obey the fundamental plane relation as well, which is mentioned in other works (Burstein et all. 1997; Graham A., 2001).

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Short talk

WIDE-FIELD PLATE DATABASE AND PRESENT EXPLOITATION OF THE ARCHIVAL PLATES

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The last development of the Wide-Field Plate Database (WFPDB) - basic source of information for archived wide-field astronomical plates worldwide obtained with professional telescopes since the application of the photography for astronomical observations is present. The WFPDB collects at the moment information for more than 510 000 photographic plates (or 24% of all existed and stored 2 200 000 wide-field plates in astronomical observatories and institutions all over the world).

In order to enable future possible investigations on the base of the WFPDB a list of observational programmes used for plate receiving is compiled. The main characteristics of these programmes is their long duration and as a result - the accumulation of large knowledge about the observed phenomena.

Some examples of use of archival wide-field plates (composed light curves of interesting stars, searching for past eruptions of a pre-main sequence star, present use of CdC plates) are listed.

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Short talk

BULGARIAN-SERBIAN COLLABORATION IN THE ASTRONOMICAL WIDE-FIELD PLATE ARCHIVING

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The wide-field plates are the basic source for information on the astronomical objects back in time. Their archiving requires cataloging and storage of plate information in digitized form. We consider here the status of archiving the wide-field plate astronomical observations in Bulgaria and Serbia in the context of their repeated use for different tasks. In this connection the question of easy access to the plate information is very important. The undertaken plate digitization with flatbed scanners with making previews for quick plate visualization and photometric scans with good resolution is based of change of ideas and experience between the Bulgarian and Serbian astronomers.

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Short talk[*]

WIDE-FIELD PLATE DATABASE: INCLUDED UKRAINIAN PLATE CATALOGUES

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The last version of the Catalogue of Wide-Field Plate Archives (June 2007) contains 43 archives stored in the observatories located in Ukraine - Crimean Astrophysical Observatory (Nauchny and Simeiz), Kyiv University Observatory, L'viv University Observatory, Main Astronomical Observatory of the National Academy of Sciences of Ukraine (Golosiiv), Nikolaev Observatory and Odessa University Observatory. About 151 000 plates were obtained in the period 1898 - 2004 in the frames of the observing programmes: Small Solar System Bodies Observations, Investigations of the Emission Nebulae and Connected Stars, Spectral Classification of the Stars and Determination of the Stellar Absorption in the Direction of the Emission Nebulae, Photographic Survey of the Northern Sky (Fotografichny Ohlyad Neba, FON), Investigation of the Kinematics and the Structure in the Main Meridian Section of the Galaxy (MEGA), Selection of Reference Stars, Artificial Satellites Observations.

Up to the moment the basic information for 13 plate catalogues of the Main Astronomical Observatory (Golosiiv, Kyiv) and Crimean Astrophysical Observatory (Nauchny and Simeiz) are included into the Catalogue of Wide-Field Plate Indexes with 12609 plates. The plate digitization is just started with MICROTEK ScanMaker 9800 XL with Transparent Media Adapter-1600 with resolution 1200 dpi. Illustrations of the potential of some Ukrainian plate catalogues for future re-usage on the basis of data retrieval from the Wide-Field Plate Database are present.

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[*] Last minute change to Poster.

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Short talk

THE CONTRIBUTION TO THEORY OF CELESTIAL MECHANICS PROBLEMS OF TWO AND THREE BODIES

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In the explanation of Definition of centripetal force (Def. *V*), Newton is stating that *the task of mathematician is to find such a force, which will keep an observed object at the given orbit, with given velocity, and the other way around: to find such curvilinear way in relation to which the given body is moved from the starting position at the given velocity*."

The obtained formula for the attraction two bodies, more general from the formula of Newton's force of gravitation. Its importance is shown in three body way at the example of determining of the force of the Sun's and the Earth's acting on the Moon.

In the standard scientific literature written: that the Sun's force is 2.5 time bigger then the Earth's one; that the lunar theory of lunar motion is the most complicated theory being constructed differently than the rest theories of planet motion; that the Moon's motion theory cannot be developed in the basic of Kepler's geocentric ellipse.

But that result contradicts to the aspects in the nature and also to the laws of classical and celestial mechanics.

The author of this paper suggests the solution of problem in theory of Moon's motion, as task system motion two and three material points from the axioms of the classical mechanics. Analytical proofs are closed to the facts that can be found in the scientific literature. Digression from completely true facts, if those facts exist at all, don't influence the author's conclusion - that the force of Earth's attraction of the Moon is larger than the force of the Sun. We have to start from our new the formula considering the fact that the eccentricity of the Moon's and the Earth's path is small, so we have to considered the motion along the circular path in the ecliptic plane. We are suggests one solution for dynamic paradox of theory of the Moon's motion from the point of the classical mechanics.

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POSTER PAPERS

Poster paper

CCD PHOTOMETRY OF MINOR PLANETS AT THE BELGRADEASTRONOMICAL OBSERVATORY 2006-2008

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In this paper a summary of activities and results in the field of CCD minor planet photometry performed with 40.6 cm f/10Schmidt-Cassegrain telescope in the period July 2006 – March 2008 at the Belgrade Astronomical Observatory is presented. Light curves were constructed and some basic parameters (rotational periods and light curve amplitudes) were obtained for 10 minor planets (9 main-belt asteroids and 1 NEO) using a five star differential photometry.

Poster paper

PHOTOELECTRIC STUDY OF THE FLARE ACTIVITY OF AD LEO

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AD Leo has been observed in 2006 and 2007 during campaigns of simultaneous observations at Bulgarian NAO–Rozhen and AO–Belogradchik. High–speed electro photometric monitoring has been carried out in U-band. Enhanced flare activity was observed. In the period January–March 2006 and optical oscillations were detected during several large flares. In this paper we present some preliminary results of our study.

Poster paper

COHERENT CATASTROPHISM THROUGH MYTH

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We argue that cometary impacts and other catastrophic astronomical events strongly influence culture and mythology. This perspective is present in the crucial oldest myths of all major world religions and traditions. We critically investigate the hypothesis of coherent catastrophism (Clube, Bailey, Napier and others). We speculate that the main icon of Mithraic religion could represent an event that happened around 4000 BC, as a time location of one such cataclysmic event.

Poster paper

MODELING OF AGN BROADE EMISSION LINES

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We present investigation of one-peaked broad line shapes of a sample of AGN. Using two-component model of Broad Line Region we are trying to determine the disk emission in these profiles. Also, we estimate the possible parameter domains of the accretion disk.

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Poster paper

CCD MEASUREMENTS OF DOUBLE AND MULTIPLE STARS AT NAO ROZHEN

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The Belgade team performed three series of observations of double and multiple stars at the Bulgarian NAO Rozhen in the period from 2004 to 2006.

The first series of observations of double and multiple stars performed with a CCD camera attached to the 2-m telescope took place in the middle of October 2004. The telescope is of the Ritchey-Chretien-Coude type with the focal length of 16 m. The frames were obtained by using the Photometrics AT200 CCD camera. The chip dimensions are 1024x1024 pixels, the pixel size is 24x24 micrometers. The angle corresponding to one pixel is 0.31 arcsec. The results have been published in (Pavlović et al. 2005).

The second series took place in the end of October 2005. The results have been published in (Cvetković et al. 2006). The third series took place on December 16/17, 2006. The results have been published in (Cvetković et al. 2007). In the second and third series the frames were obtained by using the CCD camera VersArray:1300B. The chip dimensions are 1300x1300 pixels, the pixel size is 20x20 micrometers. The angle corresponding to one pixel is 0.258 arcsec.

We presented the results for the position angle and separation for 70 double or multiple stars (129 pairs) which were measured in the three papers given below.

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Poster paper

CLASSICAL OBSERVATIONS OF LATITUDE AND THE IMPROVED REFERENCE FRAME

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It was decided at the General Assembly of IAU in 1997 at Kyoto that the International Celestial Reference Frame materializes the International Celestial Reference System from the beginning of 1998, and the HIPPARCOS Catalogue was accepted as the primary representation of the International Celestial Reference System in optical wavelengths. HIPPARCOS is one of the two catalogues (another one is Tycho) of ESA mission, and it gives for each of 118218 stars: very precise positions, proper motions, parallaxes, etc. However, nowadays we can see that the proper motions of some stars (mostly double or multiple) have problematic values because the mission was too short, less than four years. To improve these proper motions , it is possible to use also the ground-based long history optical observations of latitude/universal time variations (near 4.4 million observations of more than four thousand stars were collected), and the reference frame can be more stable. The goal is the Earth Orientation Catalogue (EOC). In this paper, we present some results of proper motions in declinations of HIPPARCOS stars observed with Photographic Zenith Tubes (PZT) throughout the 20th century.

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Poster paper

STARK BROADENING OF NEUTRAL TELLURIUM SPECTRAL LINES IN WHITE DWARF ATMOSPHERES

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With the development of astronomical observations from space, even elements like tellurium are found in stellar atmospheres, so that the broadening parameters of its spectral lines are needed for the better analyzis and synthesis of stellar spectra. In order to provide the needed spectroscopic data, we determined, Stark widths and shifts for four Te I multiplets, of interest for modellisation, investigation and diagnostic of stellar plasma, by using the semiclassical perturbation method. Results were applied for the investigation of the influence of Stark broadening mechanism in ultraviolet, optical and infrared part of the spectrum of A-type and white dwarf star atmospheres. The obtained results demonstrate that, in the considered case, Stark broadening is more important in optical and infrared, than in the ultraviolet part of the spectrum, and that this effect should be taken into account for the analysis and modeling of particular layers in A-type and white dwarf stellar atmospheres and subphotospheric layers.

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Poster paper

PHOTOMETRIC STUDY OF RY SCUTI

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The UBVR light curves of the massive eclipsing binary RY Sct, obtained at the Maidanak Observatory from 1979 to 1994, were reanalyzed in order to prove the hypothesis of the presence of an accretion disk in the system. This possibility is supported by the new spectroscopic study of Grundstrom et al. (2007), and by a specific light-curve shape exibiting a slight asymmetry around the secondary minima and a small difference in the height of the successive maxima. The light-curve analysis was performed by using a Roche model of a binary containing a geometrically and optically thick accretion disk around the more massive primary star. By solving the inverse problem, the orbital elements and the physical parameters of the system components and of the accretion disk were estimated for all individual UBVR light curves. The model gives a consistent solution for RY Sct binary system and supports the hypothesis of the existence of an optically thick disk around the massive component. Our results suggest a mass exchange between the components and a mass loss from the system. This could be considered as a possible mechanism of the formation of the accretion disk around the more massive component and of the circumstellar envelope of toroidal form in the orbital plane of the system.

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Poster paper

MODELLING THE STELLAR POPULATION IN ACTIVE GALAXIES

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We are going to present our analysis of synthetic spectrum composed of AGN and stellar population spectra. The goal of the work was to test the accuracy of extracting kinematics, age and metallicity of the stellar population in the inner kpc of active galactic nuclei, based on pixel fitting of high-resolution spectra with synthetic stellar populations. We conclude that our method can efficiently restore kinematics, age and metallicity of the stellar population, as well as the AGN contribution to the continuum.

Poster paper

OBSERVATIONS OF M81 GALAXY GROUP IN NARROW BAND [SII] AND Hα FILTERS

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We present preliminary results of the observations made with 2m telescope at NAO Rozhen, using narrow band [S II] and Hα filters. The main target was to identify supernova remnant candidates in interaction regions in M81 galaxy group, particularly in the so-called Arp's loop and Holmberg IX. Tidal interaction between galaxies in this group is supposed to led to enhanced star formation which will result in a number of supernovae, which remnants we have tried to detect.

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Poster paper

ON THE RELATION BETWEEN RADIAL ALIGNMENT OF DARK MATTER SUBHALOS AND HOST MASS IN COSMOLOGICAL SIMULATIONS

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The dependence of the radial alignment of dark matter subhalos on the mass of the their host halo is explored. In a sample of 25 well resolved host halos with masses 10^{15} h^{-1} to 10^{12} h^{-1} $M_{\odot}$ the subhalos tend to be more spherical than isolated objects and their distributions of sphericity and triaxiality of subhalos are Gaussians. It turns out, that the radial alignment is independent on host halo mass.

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Poster paper

BLUE-TO-RED STARS RATIO IN STELLAR COMPLEXES AND ASSOCIATIONS IN M33 GALAXY

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Massive stellar content of stellar complexes and associations in M33 is studied combining deep UBV photometry from the Local Group Survey (Massey et al. 2006) and JHK photometry from the 2MASS. The blue-to-red stars ratios (OB stars vs. red supergiants) and their application for deriving the star formation history in this galaxy are discussed.

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Poster paper

THE DISTORTIONS IN DENSITY PROFILES OF STAR CLUSTERS OF THE MAGELLANIC CLOUDS AND THEIR RELATION TO THEIR STRUCTURAL PARAMETERS

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The Magellanic Clouds are known to have a large variety of star clusters of various ages and morphology. Unlike the Milky Way, the Magellanic Clouds have suffered strong interactions among themselves and our galaxy through their lifetime. During those episodes, bursts of star and cluster formation has occurred, so a large number of star clusters are in the process of forming or very young still embedded in very disturbed environments and often in pairs.

A study of the imprints of such interactions has revealed that these clusters display distorted density profiles. The observed distortions and their relation to the structural parameters (central density, core radii, half-mass radii, tidal radii, Spitzer radii) of the selected clusters is discussed.

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Poster paper[*]

ENVELOPES OF COMET TRAJECTORIES

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We consider comet trajectories from the stand point of Nonstandard analysis (Leibniz's) analysis, a relatively new branch of mathematics. In particular, we consider parabolic comets paths. It appears that in a sense every parabola is an ellipse. Let **E** be an ellipse having focuses at the points (0,1) and (0,H) where H>0 is an infinite real number. Then all standard points of **E**, i.e. the points laying in the real plane R^2, R is the set of real numbers, are the points of loci of an "ordinary" parabola **P**. We show that **P** is in the fact the envelope of the family of all ellipses having one focus in (0,1), the other one in (0,*b*), *b* is a positive real number.

Here one can recognize the difficulty in determination of the nature of the comets orbits having distant second focus. In fact, the preceding example shows that every comet's orbit which is measured (observed) as parabolic actually is elliptical. But, its second focus is too remote to measure it.

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[*] Last minute change to Short talk.

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Poster paper

INFLUENCE OF THE PHASE OF THE SPHERICAL PLANET ON THE POSITION OF ITS PHOTOCENTER

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The analysis of the reasons influencing a position of photocenter of the spherical planet under various conditions of its illumination intensity and various conditions of its observations is carried out. According to the indicated reasons various methods of determination of the position of photocenter of the planet in which the photocenter of the planet is considered as center of an illuminated part of its visible disk or as light center of its disk are offered.

The considered problem for ground-based observations is solved in an orthographic approximation: boundary of a visible planetary disk is the orthographic limb, and boundary of its illuminated part – orthographic terminator.

Let's consider a diffuse reflection of light from surface of the planet and assume to a first approximation, that the brightness is uniformly distributed over the illuminated part of its visible disk.

If the observable image of a visible planetary disk is resolvable, then the photocenter of the planet will coincide with the center of an illuminated part of its visible disk.

If the observable image of a visible disk is nonresolvable (in case of the planetary satellite or the spherical asteroid), then the photocenter of this object is considered as light center of its visible disk.

If reflection of light from the surface of the planet is absolutely mirror, then in any case the photocenter of the planet will coincide with the mirror point of an illuminated part of its visible disk.

For both models of allocation of brightness over the illuminated part of the visible planetary disk the dependences of the position of photocenter on the phase angle are obtained. As a result of the analysis of these dependences some regularity of illumination of visible disks of planets are established.

The example of determination of a position of photocenter of Mercury is given.

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Poster paper

TREATING SURFACE BRIGHTNESS PROFILES IN THE FIELDS OF GLOBULAR CLUSTERS

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A discussion concerning the relationship between the surface brightness and surface mass density in the fields of globular clusters is given.

Poster paper

LONG-TERM VARIABILITY MONITORING OF THE Z ~ 0.8 QSO SDSS J0754+3033. I.OBSERVATIONS AND PHOTOMETRY

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We report preliminary results of our 4-year optical (VRI) monitoring of the flat spectrum radio quasar SDSS J0754+3033 at redshift $z = 0.80$ with the 2m-RCC telescope at the NAO Rozhen, Bulgaria. The data reduction is described, light curves and preliminary structure function analysis are presented. The quasar exhibited variations with amplitude of up to a few tenths of the magnitude during our campaign. We also obtained narrow-band images of the field searching for associated emission line objects at the redshift of the quasar.

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Poster paper

ASTRONOMY IN THE TOPLICA REGION

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In this article we present the undertakings connected with astronomy in the Toplica region. Until recently all activities were linked to the popularization and education of astronomy and other mathematical sciences. First attempts in this area rose at the beginning of the 20th century when the Gymnasium in Prokuplje was founded (1908), but they were not so successful. Here should be mentioned attempts in the twenties of Aleksa Savić, the prominent medical doctor, humanist and donator who lived in Prokuplje. First amateur telescopes were brought in Prokuplje in the beginning of seventies, and at the same time started the regular education of astronomy in high-schools. The turning point was 2001 when the amateur astronomical society ***Magellanic cloud*** was founded. Immediately the idea of rising of an astronomical station of the Astronomical observatory in Belgrade (AOB) at the mountain Vidojevica nearby Prokuplje was renewed. Soon the building of the station started due to the efforts of the staff of AOB, first of all Milan Dimitrijević (the previous director of AOB) and Zoran Knežević (the actual director of AOB) and the astronomers of the Chair for astronomy of the Faculty of mathematics of he University of Belgrade, first of all professor Stevo Šegan. The significant role in this mission played the astronomical society Magellanic cloud and the administration of the Toplica County. Popularization of astronomy was intensified and most prominent Serbian astronomers delivered public lectures there.

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Poster paper

THE PHYSICAL CHARACTERISTICS OF STARS HARBORING PLANETS

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Kolmogorov-Smirnov test is applied for samples the planet bearing stars and stars without discovered planet systems. The parametric space of mass, radius, age, rotational period, metallicity and z-coordinates is thoroughly search in order to find significant differences. These efforts focus on improving the probability to have a planet around a star based on its physical properties.

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Poster paper

BULGARIAN VIRTUAL OBSERVATORY. MULTICOLOR OBSERVATIONS OF BOX /PEANUT GALAXIES

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CCD images for 30 edge-on galaxies - with and without Box/Peanut structures are taken on the 2_m (24 galaxies) and 60_cm (17 galaxies) telescopes as follow:

(U), B, V, R, I CCD frames on the 2-m RCC telescope on Rozhen observatory with typical resolution 12"/mm = 0.62"/px with binning and rarely 0.31"/px, CCD camera "Photometrics" and (B), V, R, I frames on the 60_cm telescope on Belogradchick observatory with typical resolution of 27.5"/mm = 0.78"/px with 3x binning, CCD camera ST-8.

Every night the standards in selected clusters - M92, NGC 7790 or M67, bias, dark and flat field frames were taken to calibrate the observations.

Typical exposure times for these observations was 2 to 5 min, so the bulge/disk regions are clear visible.

All the objects, taken in the optics were reduced in the same manner as explained above. For all observed and reduced images distribution of the surface brightness were examined using MIDAS reduction package.

Basic results from these observations:

1) Ca. 25 % of the edge-on galaxies, classified as type 4 and 5 - i.e, non Box/Peanut, but ellipsoidal or impossible to classify objects in fact are type 3 Box/Peanut bulges - from the listed above these are NGC 5014, 6368, UGC 8085, 9389 and probably NGC 5610 with definitely Box/Peanut shape of the bulges, but with smaller inclination angles, so the spiral structure is clearly visible.

2) There is no significant difference in the bulge/disk shapes in the different colors, so, it is enough for detailed study to use e.g. B and R images only.

Poster paper

BULGARIAN VIRTUAL OBSERVATORY. MULTICOLOR OBSERVATIONS OF OPEN CLUSTERS IN OUR GALAXY

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Ca. 900 CCD frames in U,B,V,R,I on the 2-m RCC telescope and in B,V,R,I on the 60-cm telescope have been taken for 30 open clusters, including 7 bright clusters, 16 (8 x 2) probably double open clusters and 7 clusters in the anticenter of the Galaxy.

For photometric reduction Stetson's DAOPHOT and ALLSTAR program packages, implemented in MIDAS were used. Standards in several star clusters were used - the clusters M92 (mainly), NGC 7790, NGC 4147 an M67 and the improved standard sequences from the latest years have been taken.

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Poster paper

UNABSORBED SEYFERT 2 TYPE GALAXIES WITH AND WITHOUT HIDDEN AGN SOURCE

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We have compiled a sample of nearby unabsorbed Seyfert 2 type galaxies to investigate them whether there is hidden or nonhidden AGN source. This question in some way coincides with the presence of Hidden Broad Line Region (HBLR) and non- HBLR in Sy2. Our sample contains Sy2 type galaxies selected by two criteria: (i) Sy2's with unabsorbed X-rays which column densities are $N_H < 10^{22}$ cm^{-2}, and (ii) Sy2's with known flux f_{5007} in emission line $[OIII]\lambda 5007$. For this sample we have derived the ratio $(N_{ph}/N_{ion})_{h\nu > 55\ \mathrm{eV}}$ of the number of photons N_{ph} traced by the $[OIII]$ emission line to the number N_{ion} of high-ionization photons (with energies $h\nu > 55$ eV) provided by the central AGN source. This ratio probed the collimation hypothesis in the Unified Model and in the anisotropic case should be considerably larger than 1. We show that a large fraction of unabsorbed Sy2s in our sample possess a hidden AGN source and, also, the Sy2s with hidden AGN source have significantly smaller Eddington's ratios L_{bol}/L_{Edd}.

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Poster paper

INFLUENCE OF BARRIER FORM ON THE SHAPE OF THE GRB LIGHT CURVE PULSES

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In this contribution we will investigate the influence of shape of barrier formed by the material ejected by the decelerated shock waves, on the light curve pulses. This research is done in the frame of internal shock wave model which is broadly accepted to explain evolution and mutual interaction of relativistic shock waves in the first phase of gamma ray bursts. We have used the model which we develop in earlier work to follow the evolution and interaction of single shock wave. In order to investigate evolution of hydrodynamical parameters, as well as the effects on radiation which create light curve pulse, we replace the Gaussian profile of barrier with more suitable. Comparation and discussion with observational results is also presented.

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Poster paper

ON THE STARK BROADENING OF Cr II $3d^5$ – $3d^4$ p SPECTRAL LINES IN HOT STAR SPECTRA

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Recently, the effect of Stark broadening on the shapes of Cr II spectral line observed in stellar atmospheres of the middle part of the main sequence was investigated in Dimitrijević et al. (2007) and it was found that Stark broadening mechanism is important and should be taken into account especially in the study of Cr abundance stratification. In this paper, Stark broadening parameters for Cr II spectral lines of seven multiplets belonging to 4s-4p transitions were calculated by the semiclassical perturbation approach (Sahal-Bréchot, 1969a,b), and obtained Stark broadening parameters were applied to the analysis of Cr II line profiles observed in the spectrum of Cr-rich star HD 133792.

Taking into account the importance of Stark broadening for different types of spectroscopic studies and the particular interest of resonance transitions, we performed here calculations of its Stark widths and shifts of nine Cr II $3d^5$ - $3d^4 4p$ multiplets.

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Poster paper

A SEARCH FOR NEW STRUCTURAL COMPONENTS IN SEYFERT GALAXIES

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We present results of isophotal analysis of a number of Seyfert galaxies. We examine the contour maps and the profiles of surface brightness, ellipticity, position angle and Fourier C4 coefficient and find new components for a part of the objects.

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Poster paper

ACTIVE GALACTIC NUCLEI: RELATIONS BETWEEN NUCLEAR ACTIVITY, STAR FORMATION AND BULGE MASSES

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The evolution of massive black holes (BHs) in relation with their host galaxy is presently intensively debated. Massive black holes seem present in all galactic nuclei, independently of their level of activity. It is clear that the growth of the BH and the evolution of the host galaxy are related, so it is generally assumed that their co-evolution is mainly the result of merger events within the hierarchical scenario of large structure formation. However this scenario begins to be questioned seriously. It is indeed difficult to explain how smaller BHs grow at lower redshifts and more massive ones at higher redshifts.

Optical observations of a complete sample of X-rays selected galaxies, also detected in the far-IR, will be used to determine the mass of the black-hole (via the broad-line Hbeta characteristics) and the mass of the bulge via optical photometry and velocity dispersion, to derive the BH/bulge ratio.

The X-rays parameters will give access to the nuclear activity, while the far-IR will provide an estimate of the global star formation rate. This sample should help clarify the relations between nuclear activity and global star formation over a wide range of galaxy masses.

A regular optical photometric follow-up of some rapidly variable radio AGN's studied with VLBI would also be an essential contribution to determine the structure of the central engine (e.g. a binary black hole).

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Poster paper

EPHEMERIS CALCULATIONS CONCEPTS: CONVENTIONS AND PRACTICE IN THE PLANET'S PHYSICAL EPHEMERIDES CALCULATIONS

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In the age of intensive exploring the solar system, the many professionals and non-professionals becoming interested in calculating of basic data regarding solar system planets. We have considered some concepts of the planet’s physical ephemeris calculation as a task in a rounding of increasing number of powerful computers available to everyone. Elementary comparison among last 20 years international conventions in this calculation practice is done. As an effective result you can find interactive program for practical calculation of the planet’s physical ephemerides.

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Poster paper

GENERAL ALGORITHM FOR THE DATA PROCESSING: PHASE I: ACQUISITION, PREPROCESSING AND CORRELATION ANALYSYS PHASE II: STATISTICAL DEPENDENCES AND REGRESSION ANALYSYS

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We have considered some concepts of the expert's planning and constructing of the general algorithm for astronomical (or any other kind) data processing. The problem is solved in accordance with our knowledge that all calculations are task covered by fact of increasing number of powerful computers available to everyone. Many professionals and non-professionals becoming interested in the explicit, as possible, rules for data processing. In these articles we explain special scheme for that and follow it with some examples.

Poster paper

DIRECT DETERMINATION OF SOLAR PHYSICAL COORDINATES B_0, P FROM PHOTOHELIOGRAMS

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Sunspots observation by photoheliograms in only two weak can be used for direct determination of solar physical coordinates B_0, P if level is used for determination of horizontal line on the plate. Theory would be presented with an example.

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Poster paper

A SEARCH FOR NOVAE IN M31 WITH THE TELESCOPES OF NAO ROZHEN

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We present a long-term optical search for novae in our neighbour galaxy M31, based on observations with the 2m-RCC telescope and 50/70cm Schmidt telescope at NAO Rozhen, Bulgaria. Our monitoring of the M31 central region yields ~20% of all newly discovered novae during the last 3 years. The images were inspected manually and the photometry of the candidates was carried out with IRAF. Here we report coordinates and R-band magnitudes for 14 Nova candidates. All available data from optical and spectroscopic observations during this period are also summarized.

Poster paper

YOUNG STELLAR GROUPS IN M33 GALAXY: DELINEATION AND MAIN PARAMETERS

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The problem of (non-)existence of a typical size of the stellar associations is revisited by use of deep UBV stellar photometry in M33 from the Local Group Survey (Massey et al. 2006). Main parameters of young stellar groups like size distribution and typical density are determined and the possible hierarchical structure of recent star formation sites is discussed.

Poster paper

TOWARD A MODEL OF THE STELLAR INITIAL MASS FUNCTION (IMF) FROM DENSITY DISTRIBUTION OF MOLECULAR CLOUD CLUMPS

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Some basic steps toward creating a model of IMF are proposed. The presented preliminary results include mass distributions of protostellar clumps, assuming a power relationship between their masses and densities (rho~m^{γ}), and an approach for combined consideration of fragmentation and competitive accretion on the collapsing cores

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Poster paper

STABILITY AND EVOLUTION OF MAGNETIC ACCRETION DISK

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In this paper we consider the magneto-hydrodynamic of the hot advection accretion disk. We investigate the interaction between stream and magnetic field. Appear and activity on the instabilities in the stream is discussed. Here we will show our results for 2D radial structure of disk and local warm in disk. How the flow is develop in (r, φ)-plane on disk. We show the form of conditions for destroying of us disk to the inner edge.

POST DEAD-LINE PAPERS

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Short talk

LATITUDE VARIATIONS FOR THE PERIOD 1987.5-2008.3 AT OBSERVATORY PLANA AND THEIR INTERPRETATION

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Latitude variations at Geodetic Observatory Plana, located near to Sofia, are determined permanently since July 1987 by means of zenith telescope Zeiss 135/1750. More than 18350 observations of 72 star pairs are available now for scientific investigations. Most essential results and interpretation of the latitude variations and oscillations of the vertical at observatory Plana for the period 1987.5-2008.3 are pointed out here. Some changes of the latitude and vertical at observatory Plana are explained by the earthquakes, long-period variations of the gravity and solar activity cycles.

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Short talk

NEW TREND IN ASTROMETRY: INTELLIGENT SYSTEMS INSTEAD AUTOMATIC MEASURING MACHINES

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Modern astrometry researches based on collection of plates have been slowed down by some troubles in measuring process. Scanners and automatic measuring machines are capable to make fast data processing but still have problems of measuring of photographic plate without human's control in real time. To overcome it the intelligent decision-taking system should be constructed.
Vital differences of the proposed system are:

1. Ability for decision agenda to work in non-stop mode under list of troubles or combination of it;
2. Self-tuning system to measuring plates and objects;
3. Real time diagnostic and storing of main parameters of measuring system;
4. Verification output for experimental data in real time to control measuring process;
5. Problem-solving technique to realize non-stop mode without the assistance of operator;
6. Keeping logs with failures detected and decisions made during measuring to use them in the other applications.

As example of such system, PARSEC and future perspectives of plate scanning will be discussed.

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Short talk

THE GOLOSIIV PLATE ARCHIVE CREATION AS AN ELEMENT OF UKRAINIAN VIRTUAL OBSERVATORY. FIRST STEPS

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The preservation of the unique information kept on astronomical plates in digital form can't be achieved only by simple transformation to digital form and keeping on electronic data medium. There are several problems on this way: how to store large volume of digital archive data; how to select right method for plate digitization and criteria for data verification, to be sure original information stored on plate is preserved. The problem with linking of plate images and observation log-books data, considering different formats and errors for different instruments, should be resolved as well.

The main goal of digital archive creation, as element of virtual observatory, is to provide such information easily accessible for researchers in digital format.

We present the main methods and criteria of digital Golosiiv Plate Archive creation and scientific problems that may be resolved on it base.

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Short talk

OPTICAL OBSERVATIONS OF THE GALACTIC SUPERNOVA REMNANTS: G59.5+0.1, G84.9+0.5 AND G67.7+1.8

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In this work, the optical CCD observations and long slit spectra of the galactic supernova remnants G59.5+0.1, G84.9+0.5 and G67.7+1.8 are presented. The observations are carried out with the RTT 50 1.5 m -Russian-Turkish joint Telescope, at TUBİTAK National Observatory (TUG) in Antalya, Turkey . The optical observations of G59.5+0.1 and G84.9+0.5 are reported here as the first observations of these supernova remnants. The images are taken with Hα , [SII] and their continuum filters. After subtracting the continuum from Hα. and [SII], [SII]/Hα ratio is obtained. This average ratio is found to be 0.41 and 0.44 for G59.5+0.1 G84.9+0.5,respectively which is in a very good agrement with the ratio obtained from the optical spectra of our observations, i.e. 0.46 and 0.40, respectively, indicating that these remnants are close to, or interacting with, HII regions. G59.5+0.1 and G84.9+0.5 remnants are found to show diffuse-shell morphology while G67.7+1.8 showed arc-shell morphology. From the emission lines of the spectra, the electron density Ne, pre-shock density nc, explosion energy E, interstellar extinction E(B-V) and neutral hydrogen column density N(HI) are calculated and presented here while the shock velocity Vs is also estimated from our observations.

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Poster paper

PROCESSING AND MEASURING OF OPEN CLUSTERS PHOTO IMAGES WITH PULKOVO AUTOMATIC MACHINE "FANTASY"

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The observations of open clusters are conducted in Pulkovo from the end of the XIX century. At the present time the collection of plates contains several hundred photographs. Each plate archive is represented by series from 6 to 20-30 plates. These photographs are digitized on flatbed scanners Umax-1200 and Umax-2400 with permission 600-1200 dpi and in the measuring machine "FANTASY" (resolution 7250-8820 dpi, the position accuracy of 0.1 microns). This observational material, is used for obtaining the list of the preliminary coordinates of stars, on which then connect the systems of coordinates of plate and machine. "FANTASY" scans by the windows of 6.0x4.5 mm^2 with the overlap of sides to 10%. The complete image of the section of the celestial hemisphere with the accumulation is assembled from the separate windows, the operations of contrasting are performed. Then will recognize the images of stars on the plates of a series, plate they identify between themselves, their images are summarized. The images of stars will recognize on the summary image of accumulation, their coordinate they identify with the catalog. Then positions and photometry of stars on each plate are measured and are calculated star drifts, are separated the members of accumulation from the stars of background. All operations of working, recognition, and identification are performed automatically.

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Poster paper

ARCHIVAL PHOTOGRAPHIC OBSERVATIONS IN THE PLEIADES FIELD: AN ON-LINE ACCESS TO THE PLEIADES PLATE DATABASE AND ANALYSIS OF THE PLATE DATA

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Pleiades open cluster, one of the favorite for astronomical observations, gives a rare challenge to obtain one of the longest photometric datasets. Photographic plates in the field are taken in about one century time period, from 1885 to 2000. Using the resources of the Wide Field Plate Data Base (WFPDB), plate data and the astronomical plate archives information, we analyze the information for more than 3000 photographic plates with magnitude limit greater than 12. Time distribution as well as the magnitude limit of the plates in the observational period is presented. Pleiades Plate Database is organized and an on-line access, through the WFPDB web-page is provided.

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VI Serbian-Bulgarian Astronomical Conference (VI SBAC):
7-11 May 2008, Belgrade, Serbia

Conference will be held in the building of Mathematical faculty in Jagićeva 5

PROGRAM OF THE CONFERENCE

07. May Wednesday

18:00-19:00 **Astronomy, Poetry and Art (Milcho Tsvetkov, Milan S. Dimitrijević, Zoran Simić, Andjelka Kovačević*)***
(Library of the Astronomical Observatory, Volgina 7)

19:00 Welcome cocktail
(Library of the Astronomical Observatory, Volgina 7)

08. May Thursday

09:00-09:30 Opening ceremony

Chairman Milan S. Dimitrijević
09:30-10:00 **Milcho Tsvetkov,** Wayne Osborn**:** Incorporation the world wide-field plate archives in the VO initiatives
10:00-10:30 **Predrag Jovanović**, Luka Č. Popović: Variations in an accretion disk emissivity – repercussions to the Fe Kα line profile
10:30-11:00 **Georgi Ivanov**: Cepheid complexes of the Milky Way

11:00-11:30 Coffee break

Chairman Milcho Tsvetkov
11:30-12:00 **Ljubinko Ignjatović**, Anatolij A. Mihajlov, Milan S. Dimitrijević, Vladimir Srećković: The n-n' mixing in stellar atmospheres
12:00-12:30 **Darko Jevremović,** Peter Hauschildt, Eddie Baron, France Allard, Anatolij A. Mihajlov, Ljubinko Ignjatović, Milan S. Dimitrijević: On the modelling of astrophysical spectra using PHOENIX
12:30-12:45 Mina Koleva, Philippe Prugniel, D. Michielsen, S. de Rijcke et al.: Stellar populations in dwarf elliptical galaixes
12:45-13:00 Petya Pavlova, Kostadinka Koleva: Technique for tracking and visualization of motion in sequence of images of the Sun's crown
13:00-13:15 Nataša Stanić: Preparations for the International Astronomical Year (2009) in Serbia

13:15—15:00 Break for the lunch

Chairman Žarko Mijajlović

15:00-15:15 Dragana Ilić, Alla I. Shapovalova, Luka Č. Popović, Alexander N. Burenkov, Vahram Chavushian: Variability of the emission line shapes of NGC 4151
15:15-15:30 Svetlana Boeva, Aleksandr Antov, Rumen Bachev, Tsvetan Georgiev: On the distance of KR Aurigae
15:30-15:45 Peter Duchlev, Joanna Kokotanekova, Kostadinka Koleva, Momchil Dechev, Pawel Rudawy, Bogdan Rompolt: Kinematics of the post-eruptive phase of an eruptive prominence on 8 May 1979
15:45-16:00 Kostadinka Koleva, Peter Duchlev, Momchil Dechev: H-alpha brightness evolution during the eruption of promonences of 7 May 1979 and 8 June 1980
16:00-16:15 Stojan Obradović, Slobodan Ninković: Metaphysical ideas in physical and astronomical theories
16:15-16:30 Milan S. Dimitrijević, Magdalena Christova, Zoran Simić, Sylvie Sahal-Bréchot : On the regularities of Stark broadening parameters within spectral series: Ar I lines
16:30-16:45 Žarko Mijajlović, Nadežda Pejović, Goran Damljanović, Dušan Ćirić: Envelopes of comet trajectories

09. May Friday

09:30 Excursion to the rests of the roman town Viminacium

10. May Saturday

Chairman Luka Č. Popović

9:30-10:00 **Jan Vondrak:** Geophysical contributions in precession-nutation
10:00-10:30 **Andjelka Kovačević:** Some aspects of asteroid mass determination
10:30-11:00 **Georgi Petrov**, Momchil Dechev, Lyuba Slavcheva, Peter Duchlev, Boyko Mihov, V. Kopchev, Rumen Bachev: Astronomical virtual observatory; Bulgarian virtual observatory - place and role.
11:00-11:15 Katya Tsvetkova: Wide-field plate database and present exploitation of the archival plates
11:15-11:30 Katya Tsvetkova, Milcho Tsvetkov, Vojislava Protić-Benišek, Milan S. Dimitrijević: Bulgarian-Serbian collaboration in the astronomical wide-field plate archiving

11:30-12:00 Coffee break

Chairwoman Katya Tsvetkova

12:00-12:30 **Vlado Milićević**: Milankovic's "the end of the world"

12:30-13:00 **Valeri Golev**, Nadia Kaltcheva, Evgeni Ovcharov, M. Kontizas: Massive cluster candidates in M33: a multitelescope view

13:00-13:15 Žarko Mijajlović, Aleksandar Valjarević, Nadežda Pejović, Aleksandar Simonović: Astroclimatic conditions on the mountain Vidojevica

13:15-13:30 Veljko A. Vujičić: The contribution to the theory of celestial mechanics - on the problems of two and three bodies.

13:30—15:00 Break for the lunch

Chairman Jan Vondrak

15 :00-15 :15 Luka Č. Popović: Spectroscopical investigations of extragalactic objects at Astronomical Observatory (period 2006-2008).

15:15-15:30 Milan S. Dimitrijević: Investigations on Belgrade Observatory of the influence of collisional processes on astrophysical plasma spectra in 2006-2008.

15:30-15:45 Aytap Sezer: Optical imaging and spectroscopic observation of some galactic supernova remnants

15:45-16:00 Yavor Chapanov, Tsvetan Darakchiev: Latitude variations for the period 1987.5-2008.3 at observatory Plana and their interpretation

16:00-16:15 Jelena Kovačević, Luka Č. Popović, Milan S. Dimitrijevi**ć**: The role of optical Fe II transitions from 4f, 6s and 4g energy levels in AGN spectra

16:15-16:30 Orlin Stanchev: Fundamental plane for dwarf and normal spiral galaxies"

16:30-16:45 Coffee break

16:45-18:00 Poster session

20:00 CONFERENCE DINNER

11. May Sunday

Chairman Georgi Ivanov

11:00-11:30 **Philippe Prugniel**, Luka Č. Popović et al.: Stellar populations in active galaxies

11:30-12:00 **Andrey N. Klyucharev,** Mikhail Yu Zakharov, A. A. Matveev, Anatolij A. Mihajlov, Ljubinko Ignjatović, Milan S. Dimitrijević : Chemiionization – Experiment, Theory, Cosmical perspective

12:00-12:30 **Dušan Ćirić**: Foundation of physics on topological spaces

12:30-12:45 Aleksandr Sergeev, Tatyana Sergeeva: The Golosiiv plate archive creation as an element of Ukrainian virtual observatory. First steps

12:45-13:00 Aleksandr Sergeev: New trends in Astrometry: Inteligent systems instead automatic measuring machines

13:00 Closing ceremony

POSTER PAPERS

Yu. K. Anan'evskaya, V. N. Frolov, Evgeni V. Polyakov, Milcho L. Tsvetkov: Processing and measuring of open cluster photo images with Pulkovo automatic machine „Fantasy“

Vladimir Benišek: CCD photometry of asteroids from Belgrade Astronomical Observatory

Rumen Bogdanovski, Renada Konstantinova-Antova: Photoelectric study of the flare activity of AD Leo

Edi Bon, Nataša Gavrilović, Luka Č. Popović, Dragana Ilić: Modeling of AGN broad emission lines

Edi Bon, Milan Ćirković: Coherent catastrophism through myth

Ani Borisova, Damyan Kalaglarski, Milcho Tsvetkov: Archival photographic observations in the Pleiades Field: An on-line access to the Pleiades Plate Database and analysis of the plate data

Zorica Cvetković, Rade Pavlović, A. Strigachev, Bojan Novaković: CCD measurements of double and multiple stars at NAO Rozhen

Goran Damljanović, Nadežda Pejović: Classical observations of latitude and the improved reference frame

Milan S. Dimitrijević, Zoran Simić, Andjelka Kovačević, Miodrag Dačić, Sylvie Sahal-Bréchot: Stark broadening of neutral Tellurium spectral lines in white dwarf atmospheres

Gojko Djurašević, Ištvan Vince, Olga Atanacković: Photometric study of RY Scuti

Nataša Gavrilović: Modelling the stellar population in active galaxies

Dragana Ilić, Dejan Urošević, Bojan Arbutina, Branislav Vukotić, Konstantin Stavrev: Observations of M81 galaxy group in narrow band SII and Hα filters

A Knebe, N. Draganova, C. Power, G. Yepes, Y. Hoffman, S. Gottlober, B. Gibson: On the relation between radial alignment of dark matter subhalos and host mass in cosmological simulations

N. Koleva, Todor Veltchev, Petko Nedialkov, Blue-to-red stars ratio in stellar complexes and associations in M33 galaxy

M. Kontizas, Grigor Nikolov, A. Dapergolas, E. Kontizas, Valery Golev, I. Bellas-Velidis: The distortions in density profiles of star clusters of the Magellanic Clouds and their relation to their structural parameters.

Vladimir V. Mikhalchuk: Influence of the phase of the spherical planet on the position of its photocenter"

Slobodan Ninković, Aleksandar Valjarević: Treating surface brightness profiles in the fields of globular clusters

Evgeni Ovcharov, Antonia Valcheva, V. Ivanov, Petko Nedialkov, Tsvetan Georgiev, Ivaylo Stanev: Long-term optical monitoring of the quasar FBQSJ0754+3033

Nadežda Pejović, Aleksandar Valjarević, Žarko Mijajlović, Dušan Ćirić: Astronomy in the Toplica region

D. Petkova, Petko Nedialkov, Vladimir Shkodrov: The physical characteristics of stars harboring planets

Georgi Petrov: Bulgarian virtual observatory. Multicolor observations of Box /Peanut galaxies

Georgi Petrov, V. Kopchev: Bulgarian virtual observatory; Multicolor observations of open clusters in our Galaxy

Georgi Petrov, IvankaYankulova, Valery Golev: Unabsorbed Sy2 Galaxies with and without hidden AGN source

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Zoran Simić, Milan S. Dimitrijević, Andjelka Kovačević, Miodrag Dačić: On the Stark broadening of Cr II $3d^5 – 3d^4$ p spectral lines in hot star spectra

Luba Slavcheva-Mihova, Boyko Mihov: A search for new structural components in Seyfert galaxies

Luba Slavcheva-Mihova, Bojko Mihov, Georgi Petrov, Michel Dennefeld: Active galactic nuclei: relations between nuclear activity, star formation and bulge masses.

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Luba Vassileva, Petko Nedialkov, Todor Veltchev: Young stellar groups in M33 galaxy: delineation and main parameters

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Krasimira Yankova: Stability and evolution of magnetic accretion disk

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BALKAN PHYSICAL UNION
&
HELLENIC PHYSICAL SOCIETY

Ε.Ε.Φ.

7th GENERAL CONFERENCE OF THE BALKAN PHYSICAL UNION

Alexandroupolis 9-13 September 2009

BOOK of ABSTRACTS

With the cooperation of
THE PHYSICS DEPARTMENTS OF THE UNIVERSITIES OF ATHENS, CRETE, IOANNINA, PATRAS, THESSALONIKI
and the
PERFECTURE OF EVROS, MUNICIPALITY OF ALEXANDROUPOLIS
LOCAL UNION OF MUNICIPALITIES & COMMUNITIES OF EVROS

intrinsic polarisability, etc. Along this viewpoint, novel concepts in the field of matter-wave optics will be described, including atom interferometry at the nano-scale, non-diffracting atom waves and negative-index media ("meta-materials") for matter-wave optics. Their distinct properties (atom beam profile, group velocity characteristics, wave-packet dynamics, matter-wave's propagation...) will be analysed, comparatively to the equivalent processes in photon optics.

References:

J. Grucker *et al*, "Schlieren imaging of nanoscale atom-surface inelastic transition using a Fresnel biprism atom interferometer", Eur. Phys. J. D **47**, 427 (2008)

F. Perales *et al*, "Ultra thin coherent atom beam by Stern-Gerlach interferometry", Europhys. Lett. **78**, 60003 (2007)

J. Baudon *et al*, "Negative-index media for matter-wave optics", Phys. Rev. Lett. **102**, 140403 (2009)

ENTROPY, A UNIFYING CONCER

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ABSTRACT

Entropy, even more than energy, is a unifying concept. Energy constitutes a central concept in mechanical (classical, quantum, relativistic) systems, with important applications in physical, chemical, biological systems. The concept of entropy is even broader, since it concerns a vast class of phenomena, conservative or dissipative, in natural, artificial and social sciences. The current status of research in this area, focusing very especially on complex systems, will be briefly presented, as well as some interdisciplinary applications.

Bibliography:

(i) M. Gell-Mann and C. Tsallis, Nonextensive Entropy - Interdisciplinary Applications (Oxford University Press, New York, 2004);

(ii) J.P. Boon and C. Tsallis, Nonextensive Statistical Mechanics - New Trends, New Perspectives, Europhysics News 36 (6) (European Physical Society, 2005);

(iii) C. Tsallis, Introduction to Nonextensive Statistical Mechanics - Approaching a Complex World (Springer, New York, 2009);

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INFLUENCE OF COLLISIONS WITH CHARGED PARTICLES ON ASTRONOMICAL SPECTRA

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ABSTRACT

Broadening of spectral lines by collisions with charged particles - Stark broadening is considered and analyzed here, in particular from the aspect of stellar spectra analysis and synthesis. This line broadening mechanism is of interest e.g. for the research of white dwarfs and hot stars of A and B type, especially chemically peculiar stars. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level and consequently, Stark broadening contribution may become significant even for the Rydberg lines in the Solar spectrum. This broadening mechanism, influencing line shapes in astronomical spectra, is of significance also for the research of neutron stars and the investigation of radio recombination lines from molecular and ionized hydrogen clouds.

Line shapes enter in the models of radiative envelopes by the estimation of the quantities such as absorption coefficient, Rosseland optical depth and the total opacity cross-section per atom, so that the corresponding Stark broadening parameters are needed for the determination of these quantities for stellar plasma conditions when this broadening mechanism cannot be neglected. Stark broadening parameters are needed as well for the determination of the chemical composition of stellar atmospheres i.e. for stellar elemental abundances determination from equivalent widths of absorption lines, estimation of the radiative transfer through the stellar plasmas, especially in subphotospheric layers, and for opacity calculations. radiative acceleration considerations, nucleosynthesis research and other astrophysical topics.

For the estimation of radiative transfer through stellar plasmas, especially in subphotospheric layers as well as for the determination of chemical abundances of elements from equivalent widths of absorption lines, an as much as possible

complete set of Stark broadening data for an as much as possible larger number of spectral lines for different emitters is needed, since we do not know *a priori* the chemical composition of a star. Consequently, it is obvious that stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters. Need for the broadening data for a large number of spectral lines for trace elements and their singly and multiply charged ions is additionally stimulated by the development of space astronomy, since with instruments like Goddard High Resolution Spectrograph (GHRS) on Hubble Space Telescope, an extensive amount of high quality spectroscopic information has been and will be collected, stimulating the spectral line shape research.

Development of computers also stimulates the need for a large amount of atomic and spectroscopic data. Particularly large number of data is needed for example for opacity calculations and modeling of stellar atmospheres. For example, PHOENIX computer code for the stellar modeling includes a permanently growing database containing atomic and molecular data for several hundred millions transitions.

Results of Stark broadening research are not interesting for modeling, analysis and investigation of stellar plasma, but also for diagnostics and research of laboratory plasma, as well as fusion, laser produced and technological plasmas.

We will review and discuss also the results of Stark broadening study in Serbia, relevant to astrophysical problems. Particular attention will be paid to the results obtained within the semiclassical-perturbation and modified semiempirical methods as well as to the astrophysical aspects of research and the use in astrophysics of results and achievements in Stark broadening investigations of Serbian astronomers and physicists.

TURKISH ACCELERATOR CENTER (TAC) PROJECT

STATUS AND REGIONAL IMPORTANCE

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ABSTRACT

Turkish Accelerator Center (TAC) Project has started in 1997 with support of State Planning Organization (SPO) of Turkey under coordination of Ankara University. After completing Feasibility Report (FR, 2000) and Conceptual Design Repot (CDR, 2005), third phase of project is started in 2006 as an inter-universities project with support of SPO. Third phase of project has two main scientific goals: to write Technical Design Report (TDR) of TAC and to establish an Infrared Free Electron Laser (IR FEL) facility as a first step. TAC collaboration include ten Turkish Universities: Ankara, Gazi, _stanbul, Bo_aziçi, Do_u_, Uluda_, Dumlup_nar, Ni_de, Erciyes and S. Demirel Universities.

It is planned that the first facility will be an IR FEL & Bremsstrahlung facility based on 15-40 MeV electron linac and two optical cavities with 2.5 and 9 cm undulator magnets to scan 2-250 microns wavelength range. Main purpose of facility is to use IR FEL for research in material science, nonlinear optics, semiconductors, biotechnology, medicine and photochemical processes.

In this study, aims, regional importance, main parts and main parameters of TAC and TAC IR FEL & Bremsstrahlung projects are explained. Road map of TAC project is given. National and international collaborations are explained. The first facility and TDR studies are planned to be completed in 2012. Construction phase of TAC will cower 2013-2023.

*for TAC Collaboration (http://thm.ankara.edu.tr).

TITANIA NANOSTRUCTURES FROM FIRST-PRINCIPLES CALCULATIONS FOR PHOTOCATALYTIC AND PHOTOVOLTAIC APPLICATIONS

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We have systematically investigated structural, electronic and magnetic properties of various TiO nanostructures such as small $(TiO_2)_n$ (n=1-10) clusters, very thin TiO_x (x=1,2) nanowires as well as bulk-like (110) rutile nanowires and anatase surfaces by using the first—principles plane wave pseudopotential calculations based on density functional theory. A large number of different possible structures have been searched via total energy calculations in order to find the ground state structures of these nanostructures.

In general, ground state structures of TiO_2 nanoclusters have at least one dangling or pendant O atom. Only lowest lying structure of n=10 cluster does not have any pendant O atom. In ground state structures, Ti atoms are at least 4—fold

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NUCLEAR PHYSICS

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THE ANTIKYTHERA MECHANISM, AN ANCIENT ASTRONOMICAL INSTRUMENT AND COMPUTER

Oral presentation and Exhibition of 8 to 12 posters –panels and computers

Xenophon Moussas

Astrophysics Laboratory, University of Athens, Panepistimiopolis, GR15783 Zographos, Athens, Greece

...The origin of all technical achievements is the divine curiosity [of Socrates] and the play instinct of the working and thinking researcher as well as the constructive fantasy of the inventor... Albert Einstein, speech on the radio at the opening of the 7 Deutsche Funkausstellung in Berlin, 1930

Astronomy the oldest science developed as humans that have been watching the sky for centuries and millennia started attempting to understand all celestial motions, of the stars, the Sun, the Moon and finally the planets. This eventually led them to try to understand their existence in the Cosmos. This was the birth of Philosophy and Humanity. Humans develop calendars form prehistoric times and for this they develop mathematics and astronomy. Astronomy develops in all longitudes and latitudes, as it is an applied and practical science, necessary to regulate life and social rhythms in ancient as well as in modern societies. Humans notice the regular motions celestial bodies, stars, Sun, Moon and planets and gradually try to understand the regularity of these motions, the music of the spheres. They start to do occasional and then regular observations of the celestial bodies. They use mathematics and invent new ones. They measure the time and later start to construct astronomical models the reproduce the motions. They construct astronomical instruments, which sometimes embedded in their buildings, temples, palaces, roads of a city, so that they last long and they are available all, even the layperson who has the common knowledge of calendars and astronomy. Mathematical modeling is followed by the development of laws of nature and hence Physics is born. A new category of philosophers is born, the one that initially called physical or natural philosophers and later physicists.

The Antikythera Mechanism is the oldest known astronomical instrument and astronomical computer that we have in hands, probably made between 150 and 100 BC, by a Greek mechanic and astronomer with excellent knowledge of mathematics. It has been found in an ancient shipwreck of the 1st century BC that was on its way from Greece to Rome with tones of Greek treasures (about 100 marble and bronze statues), merchandise or official war lute. The Antikythera Mechanism looks like an oxidized grand mother's clock made of bronze gears.

The Mechanism is an Astronomical instrument suitable for: Observations, Astronomical computer Calendar mechanism, Meteorological or Climatological device, School demonstration device

Show up to friends, Measure Geographic latitude, Measure Geographic longitude (with the Moon Mechanism, Hipparchus), suitable for Cartography and Navigation

It calculates the position of the Sun, the position of the Moon, the phases of the Moon during the month, It predicts the eclipses of the Sun and the Moon.

It has several complicated calendars, based on the:Solar year (Egyptian Calendar), the four year Olympiad period, The lunisolar Saros period, 18 years 11 days and 8 hours, which predicts the solar and lunar eclipses, The lunisolar Exeligmos, 54 years and one month (equal to 3 Saros cycles) , which predicts more accurately the solar and lunar eclipses.

The lunisolar Meton's 19 years which is used today to calculate the Christian Easter, and the 19 year cycle of Hebrew calendar. The lunisolar Callippus cycles 76 years, which is multiple of Meton ′ s cycle and more accurate.

THE CONTRIBUTION OF THE ABSORPTION PROCESS TO THE OPACITY OF DB WHITE DWART ATMOSPHERES IN UV AND VUN REGIONS

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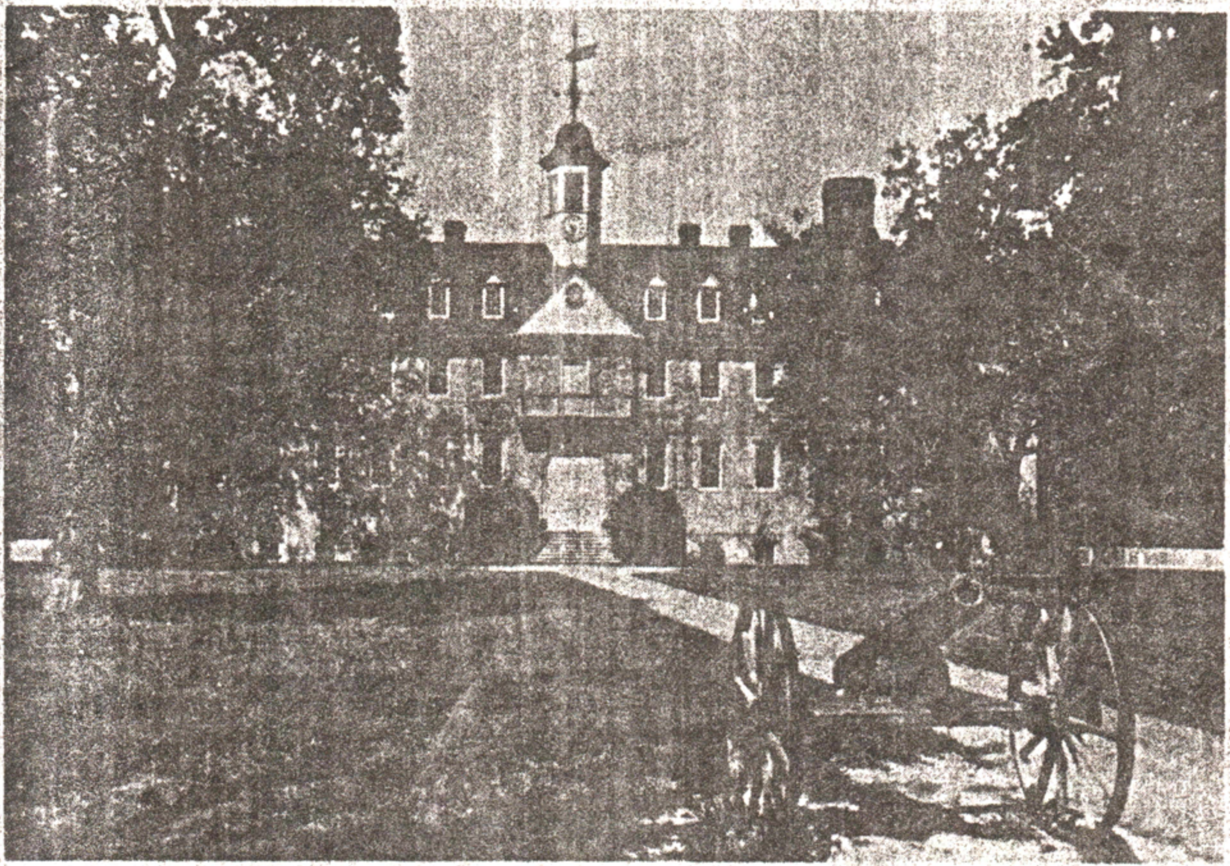
ABSTRACT

The main aim of this work is to estimate the total contribution to the opacity of DB white dwarf atmosphere of the processes of the He^{+}_{2} molecular ion photo-dissociation and $He + He^{+}$ collisional absorbtion charge exchange, and compare it with the contribution of He^{-}, and other relevant, radiative absorption processes included in standard models.

EIGHTH INTERNATIONAL CONFERENCE ON SPECTRAL LINE SHAPES



Wren Building *College of William and Mary*

June 9-13, 1986
Williamsburg, Virginia (USA)

NASA
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Program And Abstracts

STARK BROADENING OF K I: REGULARITIES WITHIN SPECTRAL SERIES

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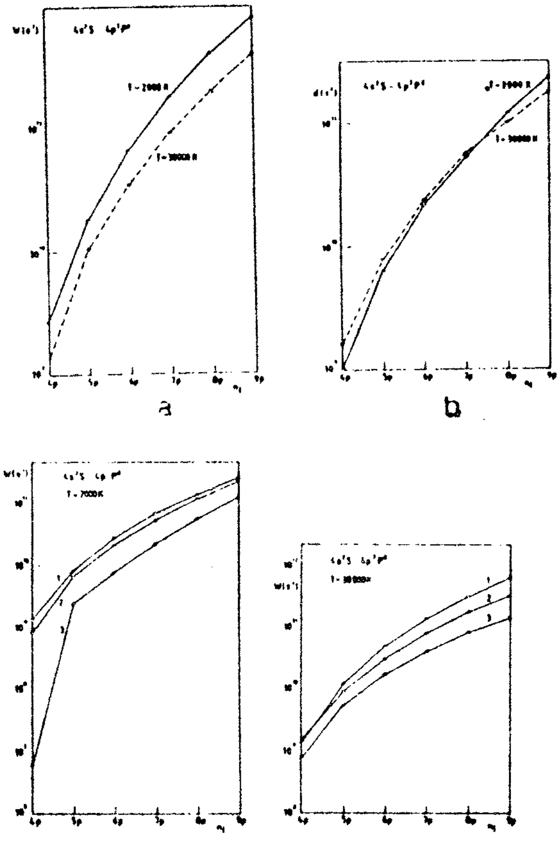
Stark broadening parameters for potassium lines are useful for a number of problems in plasma diagnostics, astrophysics, technology of high-pressure discharge lamps etc. Using the semiclassical-perturbation formalism [1,2], we have calculated Stark broadening parameters for 50 neutral K lines. Besides electron-impact widths and shifts, Stark broadening due to proton-impacts (for astrophysical purposes) and Ar II-impacts (for laboratory plasma diagnostics) have been calculated. The results obtained have also been used to continue our investigation of systematic trends among Stark broadening parameters within spectral series[3-5].

As an example of results obtained, in Figs 1a,b the behaviour of electron-impact full halfwidths and shifts within $4s\,^2S$-$np\,^2P^o$ series is illustrated for different plasma temperatures (2000 and 30,000 K). By inspecting energy separations between the upper level and the principal perturbing levels (see Grotrian diagrams in Ref. 6) we find that this value decrease gradually within a spectral series. Moreover in Figs. 1c and 1d the contributions of elastic, inelastic (for upper level only) and strong collisions to the line widths within the spectral series considered are presented for T=2000 and 30,000 K and we can see that they also change gradually. Thus we obtain a gradual change of Stark broadening parameters as expected.



a b c d

Fig. 1. Electron-impact broadening parameters for K I $4s\,^2S$-$np\,^2P^o$ lines as a function of n_j for T=2000 and 30,000 K at $N_e=10^{15}$ cm^{-3}. a) full halfwidth b) shift c) full halfwidth due to elastic-1, strong-2, and inelastic (only for upper level) collisions-3, at T=2000 K d) as in 1c but at 30,000 K.

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RADOVI
Dr Milana Dimitrijevića na kongresima, konferencijama, simpozijumima i letnjim školama

Priredili: Dr Milan Dimitrijević
Dr Slaviša Milisavljević

Beograd, 2013

УНИВЕРЗИТЕТ У БАЊОЈ ЛУЦИ
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28.-29. мај, Бања Лука,
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САДРЖАЈ

Судари емитера и апсорбера са наелектрисаним честицама и звездана плазма

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Сажетак. Судари емитера и апсорбера са наелектрисаним честицама, утичу на профиле спектралних линија звездане плазме, пошто услед цепања и померања енергетских нивоа атома у електричном пољу (Штарков ефекат) долази до ширења и померања линија у спектрима. У раду је анализирана важност Штарковог ширења овакви линија за анализу, интерпретацију и синтезу звезданих спектара, анализу, дијагностику и моделирање звездане плазме и значај оваквих резултата за истраживања лабораторијске, фузионе и технолошких плазми као и за физику ласера. Размотрено је код каквих типова звезда и при којим истраживањима је Штарково ширење значајно и дискутовани су методи за теоријско одређивање параметара ширења спектралних линија. Такође је дат и преглед оваквих истраживања на Астрономској опсерваторији у Београду.

Кључне речи: Штарково ширење, профили линија, звездане атмосфере, бели патуљци, радио рекомбинационе линије, неутронске звезде, атомски подаци, базе података
PACS: 32.60.+j, 32.70.Jz, 52.20.Fs, 95.80.+p, 97.20.-w, 97.60.-s

1. УВОД

Спектрална линија није никада монохроматска. Увек је проширена због неколико разлога. Хајзенбергова релација неодређености показује да не можемо апсолутно тачно познавати координату и импулс честице. Може се показати (види нпр. [1]) да се ова релација може тако трансформисати да повезује ширину енергетског нивоа у атому и време живота електрона у таквом енергетском стању, односно што је време живота електрона краће то је енергетски ниво шири. Пошто је само у основном стању време живота електрона толико дуго да можемо да кажемо да његова ширина тежи нули, све спектралне линије имају неку ширину због ширине енергетских нивоа прелаза којим су настале. Таква ширина се назива природна и не зависи од температуре и густине честица (притиска) већ само од унутрашњих особина атома или јона који зрачи.

Осим овог узрока, линије могу бити проширене и услед Доплеровог ефекта. Пошто се емитери крећу хаотично, сваки емитовани фотон ће имати неки црвени или плави помак у зависности од компоненте брзине у правцу посматрача. Када се ови помаци саберу добиће се проширена спектрална линија. Профил доплеровски проширене линије је Гаусов, пошто је то расподела која описује случајне процесе или догађаје и овај механизам ширења зависи од температуре емитера.

Судари такође доводе до ширења спектралних линија и овакви механизми ширења зависе од концентрације честица које пертурбују емитујући/апсорбујући атом или јон, односно притиска, па се једним именом зову ширење притиском. То су Штарково ширење услед судара са наелектрисаним честицама, Ван дер Валсово ширење или ширење сударима са неутралним атомима и резонантно ширење (види нпр. [1]).

Занимљиво је колико података о звездама можемо сазнати анализом њиховог спектра. Анализом спектралних линија можемо одредити температуру звездане плазме, односно појединих слојева звездане атмосфере, њен хемијски састав и површинску гравитацију. Можемо боље разумети нуклеарне процесе у њеној унутрашњости, и одредити њен спектрални тип и ефективну температуру упоређивањем спектра звезде са стандардним спектрима за поједине типове.

Истраживање Штарковог ширења је развијена научна област у Србији и бившој Југославији, која има критичну масу научника, и захваљујући и свом мултидисциплинарном значају пружа добру основу за успешну сарадњу. Аутор је публиковао преглед истраживања облика спектралних линија у Србији и Југославији са библиографијом и индексом цитата за период од првог рада објављеног 1962. до краја 2000. године [2-6]. У том периоду је регистровано 1427 (1222 од српских аутора) библиографских јединица које је објавило 179 југословенских аутора (152 из Србије, 26 из Хрватске и један Македонац који живи у Француској). Већина ових радова односи се на Штарково ширење.

У овом раду размотриће се значај Штарковог ширења за истраживања астрофизичке плазме и рад у овој научној области на Астрономској опсерваторији у Београду у Групи за Астрофизичку спектроскопију.

2. УСЛОВИ У АСТРОФИЗИЧКОЈ ПЛАЗМИ И ШТАРКОВО ШИРЕЊЕ

Хенри Расел је 1926. објавио у Астрофизичком журналу чланак [7] са анализом спектра Fe II у коме је пронашао 61 енергетски ниво на основу 214 спектралних линија јонизованог гвожђа. У њему је написао да су сада „све линије од астрофизичког значаја класификоване“. Ипак, 1988. је у чланку Јохансона [8], изјављено да сада познајемо 675 енергетских нивоа Fe II, али да је 50% појединачних спектралних облика у астрофизичким спектрима високе резолуције, још некласификовано.

То је последица чињенице, да су услови у астрофизичким плазмама невероватно разноврсни у поређењу са изворима лабораторијске плазме. Сходно томе, ширење спектралних линија услед интеракције између емитера/апсорбера и наелектрисаних честица (Штарково ширење) у астрофизици је од интереса у плазмама у тако екстремним условима као што су они у међузвезданим облацима молекуларног водоника или у атмосферама неутронских звезда, какви се не могу добити у лабораторијама.

Типичне електронске температуре у међузвезданим молекуларним облацима су око 30 K или мање, а типичне електронске густине су 2-15 cm^{-3}. У таквим условима, јон може да захвати слободне електроне (рекомбинација) у веома удаљену орбиту са главним квантним бројем (n) чија је вредност неколико стотина, па и већа од хиљаду и да се каскадно деексцитује на енергетске нивое n-1, n-2,... зрачећи у радио домену. Такви удаљени електрони су слабо повезани са језгром и на њих могу утицати веома слаба електрична микропоља. Сходно томе, Штарково ширење може бити значајно (види нпр. [9]).

У међузвезданим облацима јонизованог водоника, електронске температуре су око 10 000 K, а електронске густине реда 10^4 cm^{-3} [10]. На одговарајуће серије блиских радио рекомбинационих линија које потичу са енергетских нивоа са великим вредностима n (неколико стотина па и веће од хиљаду) утиче Штарково ширење [10].

За $T_{eff} > 10^4$ K, водоник, главни конституент звезданих атмосфера је углавном јонизован, и међу сударним механизмима ширења спектралних линија, доминантан је Штарков ефекат. То је случај за беле патуљке и вреле звезде O, B и A типа. Чак и у атмосферама хладнијих звезда, као што је Сунце, Штарково ширење може бити значајно. На пример утицај Штарковог ширења у спектралним серијама расте са порастом главног квантног броја горњег нивоа [11-13] и за линије са већом вредношћу овог квантног броја допринос Штарковог ширења је значајан и у Сунчевом спектру [14-16].

На пример спектралне линије - високи чланови Балмерове серије могу се употребити као моћно дијагностичко средство за проучавање звезданих атмосфера. У раду Фелдмана и Дошека [17], употребљени су профили чланова Балмерове серије са главним квантним бројем n између 16 и 32 (на које значајно утиче Штарков ефекат), да би се одредила електронска густина и температура изнад активне области на Сунцу. Опсег густина (у cm^{-3}) и температура (у K) од значаја за радијативне омотаче A и F звезда је $10^{14}\ \mathrm{cm}^{-3} \leq N_e \leq 10^{16}\ \mathrm{cm}^{-3}$; $10^4\ \mathrm{K} \leq T \leq 4\mathrm{x}10^5\ \mathrm{K}$ [18].

Бели патуљци DA и DB типа имају ефективне температуре између око 10 000 K и 30 000 K тако да је Штарково ширење од значаја за интерпретацију и синтезу њихових спектара и за истраживање, моделирање и анализу њихових атмосфера. Спектри патуљака DA типа карактеришу се широким водониковим линијама (нпр. [19]), а код DB типа у спектру доминирају линије неутралног хелијума. Занимљиво је да је у спектрима белих патуљака откривено Земаново ширење, кога нема у лабораторијским спектрима [20]. Бели патуљци DO типа имају ефективне температуре од приближно 45000 K до око 120 000 K [21] и за истраживање плазме њихових атмосфера Штарково ширење може да буде веома значајно [22].

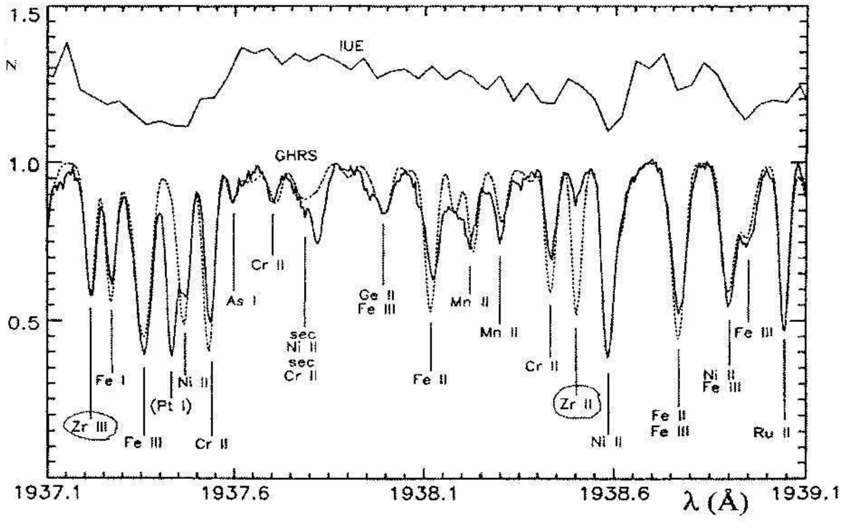
Међу најтоплије звезде спадају оне типа PG1159, врели пре-бели патуљци са мањком водоника, чија ефективна температура се налази у опсегу од T_{eff} = 100 000 K (нпр. за PG1424+535 и PG1707+427) до T_{eff} = 140 000 K (за PG1159-035 и PG1520+525), где је свакако Штарково ширење изузетно важно [23]. Ове звезде имају велику површинску гравитацију ($\log g = 7$), и у њиховим фотосферама доминира хелијум и угљеник са знатним додатком кисеоника (C/He = 0.5 и O/He = 0.13) [23]. У њиховим спектрима, на које јако утиче Штарково ширење, доминирају линије He II, C IV, O VI и N V.

У атмосферама неутронских звезда, густина материје, електронска концентрација и температура су за редове величине већи него у атмосферама белих патуљака, и типичне су за унутрашњост звезда. Температуре на којима се одвија емисија из фотосфере су реда 10^6 - 10^7

K, а електронске густине реда 10^{24} cm^{-3} [24,25]. У реф. [25], финални профил за хелијуму сличну резонантну линију гвожђа је описан помоћу Фогтовог профила, са укупним параметром пригушења једнаким суми природног и Штарковог (судари са електронима) ширења.

3. ПОТРЕБЕ У АСТРОФИЗИЦИ ЗА ВЕЛИКИМ СКУПОМ ПОДАТАКА О ШТАРКОВОМ ШИРЕЊУ

Јасно је да звездана спектроскопија зависи од веома великог броја прелаза за различите атоме и јоне са подацима о њиховим атомским параметрима и Штарковом ширењу што је посебно стимулисано развојем космичке астрономије, пошто је помоћу инструмената као што је Годаров спектрограф велике резолуције (Goddard High Resolution Spectrograph - GHRS) на Хабловом космичком телескопу (Hubble Space Telescope), прикупљен велики скуп спектроскопских података високог квалитета, који стално расте, стимулишући истраживања спектралних линија. То се може лепо илустровати упоређивањем ултра љубичастих спектара χ Lupi добијених помоћу уређаја на сателиту IUE (International Ultraviolet Explorer) и GHRS (сл. 1). Треба узети у обзир да је на сл. 1 приказан део спектра широк само 2 ангстрема и упоредити квалитет посматраних профила спектралних линија.



СЛИКА 1. *УВ спектар звезде χ Lupi добијен помоћу GHRS и помоћу IUE сателита [26]. Резолуција GHRS спектра је 0.0023 nm а максимални однос сигнал/шум је 95 [27]. На GHRS спектру пуном линијом је означен посматран а тачкастом синтетизовани.*

Развој компјутера такође стимулише потребу за великом количином атомских и спектроскопских података. Нарочито велики број података је потребан на пример за прорачун непрозрачности звезданих атмосфера. Илустративан пример може бити чланак о прорачуну непрозрачности за класичан модел цефеида [28], где је у обзир било узето 11 996 532 спектралних линија. Други добар пример колико је велики скуп атомских и спектроскопских података неопходан, је моделирање звезданих атмосфера. На пример компјутерски програм PHOENIX (види [29] и референце у чланку) за моделирање звезданих атмосфера, укључује базу података која садржи податке о 4.2×10^7 атомских, јонских и молекуларних прелаза.

Занимљива истраживања, која показују могућности које се отварају са развојем компјутерских технологија, и указују потребу за што је могуће већим скупом спектроскопских и атомских података, су прорачуни промена еквивалентних ширина са временом у звезданим јатима и галаксијама, „породилиштима“ (starburst) звезда [30]. У овим истраживањима, рачуната је промена еквивалентних ширина појединих водоникових и хелијумових линија у току 500 милиона година, и поређена са посматрањима звезданих јата и галаксија „породилишта“ звезда. Прорачуни су изведени у два корака. Прво су израчунате популације звезда различитих спектралних типова у функцији времена, а онда су профили спектралних линија синтетизовани додајући различите доприносе појединих спектралних типова звезда. Приликом синтезе профила спектралних линија, узети су у обзир природно, термално Доплерово, Штарково, и ширење линија услед судара са неутралним атомима.

За прорачун преноса зрачења кроз звездану плазму, нарочито у субфотосферским слојевима, као и за одређивање хемијске обилности елемената помоћу апсорпционих линија, потребан је што је могуће потпунији скуп података за што је могуће већи број спектралних линија различитих емитера односно апсорбера, пошто ми не знамо унапред хемијски састав проучаване звезде.

4. ИСТРАЖИВАЊА ЗВЕЗДАНЕ ПЛАЗМЕ

Профили спектралних линија улазе у моделирање слојева звездане атмосфере у оквиру процене величина као што су коефицијент апсорпције κ_ν, Роселандова оптичка дубина τ_{Ross} и укупни пресек за непрозрачност по атому σ_ν. Узмимо да је правац деловања гравитације у звезданој атмосфери z-оса. Ако је атмосфера у макроскопској механичкој равнотежи, а са ρ означимо густину гаса, оптичка дубина је

$$\tau_\nu = \int_z^\infty \kappa_\nu \rho \, \mathrm{dz}$$

$$\kappa_\nu = N(A,\ i)\phi_\nu \frac{\pi e^2}{mc} f_{ij},$$

κ_ν је коефицијент апсорпције на фреквенцији ν, $N(A,i)$ је запреминска густина емитера у стању i, f_{ij} је јачина осцилатора у апсорпцији, m је маса електрона и ϕ_ν профил спектралне линије.

Пресек укупне непрозрачности по атому је

$$\sigma_\nu(op) = M\kappa_\nu,$$

где је M средња маса атома, а непрозрачност по јединици дужине је

$$\rho\kappa_\nu = N\sigma_\nu(op),$$

Уведимо као независну променљиву средњу оптичку дубину

$$\tau_{Ross} = \int_z^\infty \kappa_{Ross} \rho \, \mathrm{dz}.$$

За Роселандову средњу оптичку дубину τ_{Ross}, κ_{Ross} је дефинисано као

$$\frac{1}{\kappa_{Ross}} \int_0^\infty \frac{\mathrm{d}B_\nu}{\mathrm{d}T} \mathrm{d}\nu = \int_0^\infty \frac{1}{\kappa_\nu} \frac{\mathrm{d}B_\nu}{\mathrm{d}T} \mathrm{d}\nu,$$

$$B_\nu(T) = \frac{2h\nu^3}{c^2}(e^{h\nu/kT} - 1)^{-1}.$$

Сада је Роселандов средњи пресек непрозрачности

$$\sigma_{Ross} = M\kappa_{Ross},$$

Параметри Штарковог ширења су такође потребни за одређивање хемијског састава звезданих атмосфера, односно за одређивање звездане обилности хемијских елемената. Метод који користи синтетичке и посматране спектре и подешавање параметара модела атмосфере да би се добило најбоље слагање, добро је развијен и примењиван на много звезда. Нађено је да постоје хемијски нерегуларне звезде, посебно у интервалу спектралних класа F0-B2 [31], код којих се обилности појединих елемената разликују за неколико редова величине од Сунчевих. Такође је пронађено да је површина CP звезда хемијски нехомогена, тако да је уведен локални хемијски састав, који зависи од координата на звезданој површини [31,32]. Такве неправилности се углавном објашњавају дифузионим механизмом, који делује у звезданим омотачима и (или) атмосферама, као и разликама у радијативном убрзању појединих елемената [33]. Радијативно убрзање g_r на ν, у интервалу фреквенција $\mathrm{d}\nu$, које делује на елемент A (чија је густина $N(A)$, а маса m_A је [34]

$$m_A g_r = \frac{\kappa_\nu(A)}{N(A)} \Phi_\nu \frac{\mathrm{d}T}{c},$$

где је $\kappa_\nu(A)$ допринос A монохроматском коефицијенту апсорпције, а Φ_ν флукс зрачења. У непрозрачном омотачу радијуса r, флукс зрачења је приближно једнак [34]

$$\Phi_\nu = \frac{4\pi}{3} \frac{1}{\rho \kappa_\nu} \frac{\partial B_\nu}{\partial T} \left(\frac{-\partial T}{\partial r} \right),$$

$$\kappa_\nu = \kappa_\nu(A) + \kappa_{rest},$$

где су са κ_{rest} означени остали доприноси укупном коефицијенту апсорпције, поред $\kappa_\nu(A)$. Већина CP звезда су A и B спектралног типа, код којих је Штарково ширење главно од механизама ширења притиском.

5. НЕУТРОНСКЕ ЗВЕЗДЕ

Са побољшаном осетљивошћу рендгенских уређаја у космосу, расте интерес за спектралне линије код атмосфера неутронских звезда. Пошто је карактеристична густина у атмосфери директно сразмерна гравитационом убрзању на звезданој површини, мерењем ширења притиском апсорпционих линија директно се мери M/R^2, где су M и R маса и радијус звезде. Када се то повеже са мерењем гравитационог црвеног помака (пропорционалног са M/R), за исту или било коју другу линију или скуп линија, могу се одредити маса и радијус. Оваква мерења масе и радијуса не укључују удаљеност неутронске звезде, која је често недовољно прецизно позната, као ни величину емитујуће области [34].

Да бисмо добили грубу процену ширине спектралне линије за атмосферу неутронске звезде, можемо да проценимо ширину услед деловања најближег суседа (на растојању r_{nn}). Енергетска ширина линије Lyα коју изазива пертурбер са наелектрисањем z је [34]

$$W_{Stark} = \frac{6a_0 ze^2}{Zr_{nn}^2} = 6\left(\frac{4\pi}{3}\right)^{2/3} \frac{a_0 ze^2}{Z} N_{pert}^{2/3}\ \text{eV}.$$

Овде је N_{pert} густина пертурбера, а Z наелектрисање језгра јона.

Ако изаберемо јединицу дубине Томсоновог расејања као одговарајућу референтну тачку, и интегришемо једначину хидростатичке равнотеже за изотермалну атмосферу температуре T, добија се да је карактеристична електронска густина за атмосферу неутронске звезде [34].

$$N_e = \frac{\mu m_p g}{\sigma_T kT} = 3.4\times 10^{24} \mu M_{1.4} T_6^{-1} R_6^{-2}\ \text{cm}^{-3}$$

Овде је μ средња маса по честици у јединицама масе протона m_p, g је гравитационо убрзање, σ_T Томсонов пресек, k Болцманова константа, $M_{1.4}$ маса звезде у јединицама 1.4 масе Сунца, R_6 радијус у јединицама 10^6 cm, и T_6 температура атмосфере у јединицама 10^6 K.

У квазистатичкој апроксимацији [34], претпостављајући да су електронско и јонско ширење упоредиви, Штаркова ширина спектралне линије за плазму у којој доминира водоник (z=1, $N_{pert} = N_e$, μ =1/2) је [34]

$$W_{Stark}\ [\text{eV}] = 163\ Z^{-1}(M_{1.4})^{2/3}(R_6)^{-4/3}(T_6)^{-2/3}\ \text{eV}.$$

Перелс [34] је за Lyα линију водонику сличног кисеоника нашао типичну Штаркову ширину од 20 eV, а од 60 eV за Lyβ.

6. ПРИМЕНА СЕМИКЛАСИЧНОГ МЕТОДА ЗА ИСТРАЖИВАЊЕ ШТАРКОВОГ ШИРЕЊА СПЕКТРАЛНИХ ЛИНИЈА У СРБИЈИ И АСТРОФИЗИЧКИ ЗНАЧАЈ ДОБИЈЕНИХ РЕЗУЛТАТА

Упркос чињеници да је најбољи теоријски метод за одређивање штарковски проширених профила спектралних линија квантно – механички метод јаке спреге, услед његове комплексности и нумеричких тешкоћа, постоји само мањи број оваквих прорачуна (види на пример референце у [36] као и [37-41]). Као пример доприноса чланова Групе за астрономску спектроскопију на Астрономској опсерваторији у Београду, можемо навести прво одређивање параметара Штарковог ширења у оквиру квантно-механичке теорије јаке спреге за један неводонични неутрални емитер (спектрална линија Li I 2s ^{2}S - 2p ^{2}P^o [42]).

У многим случајевима, као што су на пример комплексни спектри тешких атома или прелази између високопобуђених нивоа, квантно-механички метод је веома тешко, а често и практично немогуће употребити, те у таквим случајевима семикласични метод остаје најефикаснији метод за одређивање параметара Штарковог ширења.

Постојећи прорачуни већег обима изведени су коришћењем три различита компјутерска програма које су у основи разрадили (i) Џонс, Бенет и Грим (Jones, Benett и Griem [43-45]), (ii) Саал-Брешо (Sahal-Bréchot [46,47]) и (iii) Басало, Катани и Валдер (Bassalo, Cattani и Walder [48]).

Да би обезбедили што већи број података о Штарковом ширењу, потребних за истраживања астрофизичке и лабораторијске плазме, прорачун звезданих непрозрачности и моделирање атмосфера ових објеката, чинимо непрекидан напор да одредимо параметре Штарковог ширења за велики број линија у спектрима атома и јона. У низу радова, користећи семикласични пертурбациони формализам [46,47] који је био иновиран, осавремењен и оптимизован више пута (види нпр. [36,49-51]), одредили смо параметре Штарковог ширења за прелазе за које постоји довољно комплетан скуп поузданих атомских података, тако да се очекује добра тачност резултата (види на пример референце у [36] као и [52]).

До сада су публиковани резултати за 79 He, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 189 Ca, 32 Zn, 6 Au, 48 Ag, 18 Ga, 70 Cd I, 9 Cr I, 4 Te I, 25 Ne I, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 22 Ne II, 5 F II, 1 Cd II, 1 Kr II, 2 Ar II, 7 Cr II, 12 B III, 23 Al III, 10 Sc III, 27 Be III, 5 Ne III, 32 Y III, 20 In III, 2

Tl III, 5 F III, 2 Ne IV, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 2 Pb IV, 19 O V, 30 N V, 25 C V, 51 P V, 34 S V, 16 Si V, 26 V V, 26 Ne V, 30 O VI, 21 S VI, 2 F VI, 15 Si VI, 14 O VII, 10 F VII, 10 Cl VII, 20 Ne VIII, 4 K VIII, 9 Ar VIII, 6 Kr VIII, 4 Ca IX, 30 K IX, 8 Na IX, 57 Na X, 48 Ca X, 4 Sc X, 7 Al XI, 4 Si XI, 18 Mg XI, 4 Ti XI, 10 Sc XI, 9 Si XII, 27 Ti XII, 61 Si XIII и 33 V XIII појединачних спектралних линија и мултиплета.

Добијени семикласични резултати су упоређени са критички изабраним експерименталним подацима за 13 мултиплета He I [53]. Разлике између семикласичних резултата и експерименталних вредности су унутар граница од ± 20%, што су и предвиђене границе тачности семикласичног метода [45]).

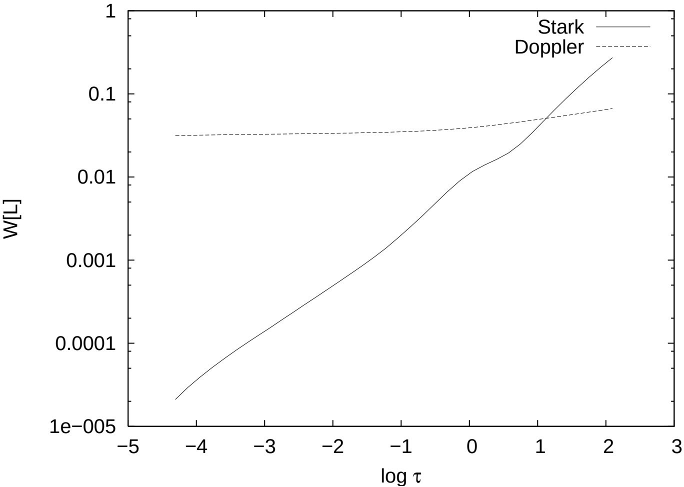
7. ПРИМЕНА ПАРАМЕТАРА ШТАРКОВОГ ШИРЕЊА ОДРЕЂЕНИХ СЕМИКЛАСИЧНИМ ПЕРТУРБАЦИОНИМ МЕТОДОМ ЗА ИСТРАЖИВАЊЕ УТИЦАЈА ОВОГ МЕХАНИЗМА ШИРЕЊА У ЗВЕЗДАНИМ АТМОСФЕРАМА

У низу радова истраживан је утицај Штарковог ширења на Au II [54], Co III [55], Ge I [56], Ga I [57], Cd I [58] и Te I [59] спектралне линије у спектрима атмосфера хемијски нерегуларних звезда А типа и за сваки испитивани спектар нађени су атмосферски слојеви, где је допринос овог механизма доминантан или се не може занемарити. Као модел хемијски нерегуларне звездане атмосфере А типа, у поменутим радовима је коришћен модел са условима у плазми блиским HgMn звезди А типа χ Lupi. Таква истраживања су изведена и за атмосфере белих патуљака DA, DB и DO типа [54, 55, 60], и установљено је да је за такве звездане атмосфере Штарково ширење доминантно у односу на Доплерово, у практично свим релевантним атмосферским слојевима.

Као пример утицаја Штарковог ширења у атмосферама врелих звезда на Сл. 2 је Штаркова ширина Te I 6s $^5S^o$ - 6p ^5P (9903.9 Å) мултиплета, упоређена са Доплеровом за модел (T_{eff} = 10000 K, log g = 4.5) атмосфере звезде спектралног типа А [61]. Наиме у атмосферама врелих звезда, Доплерово ширење је важан конкурентни механизам ширења спектралних линија, и упоређивањем Штаркове и Доплерове ширине може се закључити о значају ових механизама ширења. Треба имати у виду да се профил Доплеровски проширене линије описује Гаусовом расподелом а Штарковски проширене Лоренцовом. Због особина ове две расподеле, чак и када је Штаркова ширина линије мања од Доплерове, овај механизам може да утиче на крила линије. Резултати

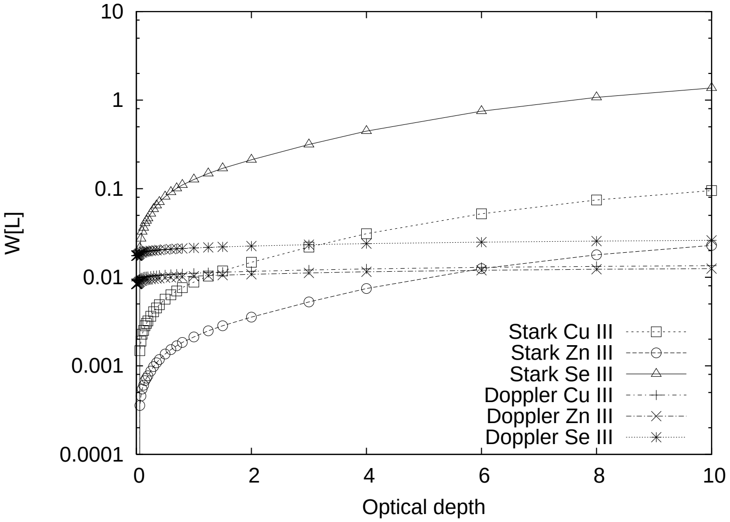
Симића и др. [59], представљени су на Сл. 2 у функцији Роселандове оптичке дубине – log τ. Може се видети да је механизам Штарковог ширења апсолутно доминантан у поређењу са термалним Доплеровим, у дубљим слојевима звездане атмосфере.

Утицај Штарковог ширења на линије Cu III, Zn III и Se III у спектрима атмосферама DB белих патуљака, истраживали су Симић и др. [58] за Cu III 4s ^{2}F - 4p ^{2}G^o (λ=1774.4 Å), Zn III 4s ^{3}D - 4p ^{3}P^o (λ=1667.9 Å) и Se III 4p5s ^{3}P^o - 5p ^{3}D (λ=3815.5 Å), користећи модел атмосфере са T_{eff} = 15000 K и log g = 7 [62]. За разматрани модел атмосфере DB белих патуљака мрежа тачка за оптичку дубину дата је у реф. [62] за стандардну таласну дужину λ_s=5150 Å (τ_{5150}) па је оптичка дубина тако претстављена и код Симића и др. [58].

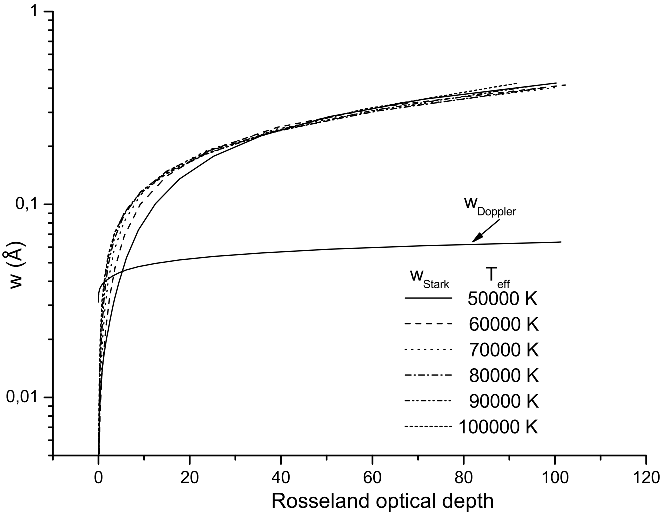


СЛИКА 2. *Термална Доплерова и Штаркова ширина за Te I 6s ^{5}S^o - 6p ^{5}P (9903.9 Å) мултиплет у функцији оптичке дубине за звезду спектралног типа A. (T_{eff} = 10000 K, log g = 4.5).*

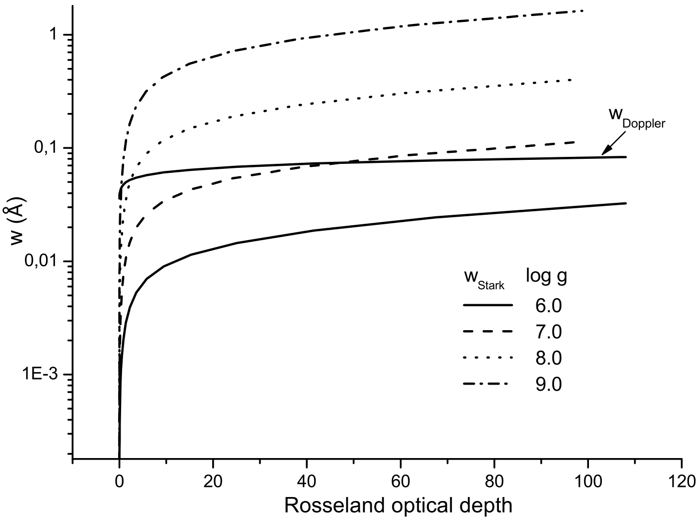
Као што се може видети на Сл. 3, за услове у плазми атмосфере DB белих патуљака термално Доплерово ширење има много мањи значај у поређењу са Штарковим ширењем. На пример Штаркова ширина за разматрану Se III 3815.5 Å линију је већа од Доплерове и до два реда величине у оквиру посматраног опсега оптичких дубина. Много веће Штаркове ширине у атмосферама DB белих патуљака, у поређењу са звездама спектралног типа A, су последица већих електронских густина услед много веће површинске гравитације и ефективне температуре,



СЛИКА 3. *Термална Доплерова и Штаркова ширина за спектралне линије Cu III 4s* ^2F *- 4p* $^2G^o$ *(*λ*=1774.4 Å), Zn III 4s* ^3D *- 4p* $^3P^o$ *(*λ*=1667.9 Å) и Se III 4p5s* $^3P^o$ *- 5p* ^3D *(*λ*=3815.5 Å), за модел атмосфере DB белог патуљка са* T_{eff} *= 15 000 K и log g = 7, у функцији оптичке дубине* τ_{5150}*.*



СЛИКА 4. *Штаркова и Доплерова ширина за спектралну линију Si VI 2p*^{4}*(*^{3}*P)3s* ^2P*-2p*^{4}*(*^{3}*P)3p* $^2D^\circ$ *(*λ *= 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за шест модела DO белих патуљака са ефективним температурама* T_{eff} *= 50 000–100 000 K и log g = 8.*



СЛИКА 5. *Штаркова и Доплерова ширина за спектралну линију Si VI* $2p^4(^3P)3s\ ^2P\text{-}2p^4(^3P)3p\ ^2D^{\circ}$ *(*λ *= 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за четири модела DO белих патуљака са log g = 6–9 и* T_{eff} *= 80 000 K.*

тако да је механизам ширења спектралних линија услед судара са електронима (Штарков) много ефективнији.

Хамди и др. [22] истраживали су утицај Штарковог ширења на Si VI линије у спектру DO белих патуљака за 50000 K $\leq T_{eff} \leq$ 100000 K и 6 $\leq$ log g $\leq$ 9. Установљено је да утицај расте са порастом log g и доминантан је у великим областима разматраних атмосфера, чији су модели узети из рада Весемела (Wesemael) [63].

На Сл. 4 и 5 представљене су Штаркова (FWHM) и Доплерова ширина за спектралну линију Si VI $2p^4(^3P)3s\ ^2P\text{-}2p^4(^3P)3p\ ^2D^{\circ}$ (λ = 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за шест модела DO белих патуљака са ефективним температурама T_{eff} = 50 000–100 000 K и log g = 8 и четири модела са log g = 6–9 и T_{eff} = 80 000 K. За моделе звезданих атмосфера са већим вредностима површинске гравитације (log g = 8–9), Штарково ширење је знатно веће од Доплеровог. За звездане атмосфере са површинском гравитацијом log g = 7, Штаркове ширине су упоредиве са Доплеровим само за дубље, врелије слојеве. За моделе атмосфера са log g = 6, Доплерово ширење је доминантно за све анализиране слојеве атмосфере.

8. УТИЦАЈ ШТАРКОВОГ ШИРЕЊА И СТРАТИФИКАЦИЈЕ НА ЛИНИЈЕ Si I КОД roAp ЗВЕЗДЕ 10 Aql

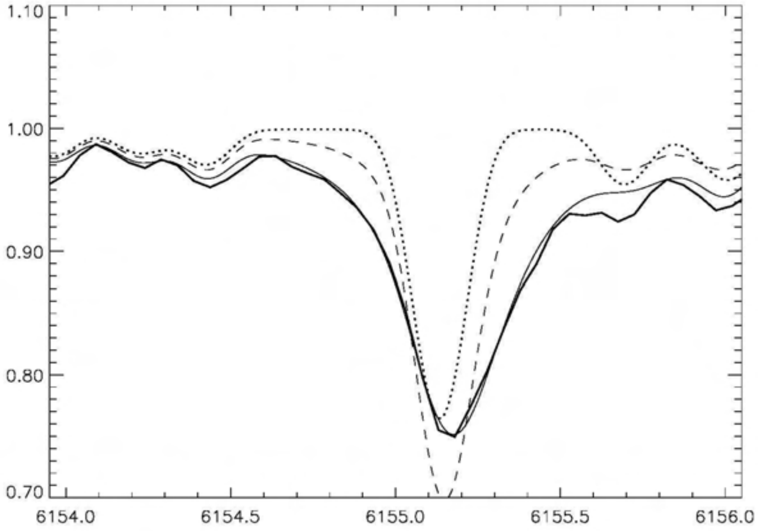
Као пример примене података о Штарковом ширењу у астрофизици може да послужи реф. [64] где је проучен утицај хемијске раслојености односно стратификације и Штарковог ширења на спектралне линије Si I, код брзо осцилујуће roAp звезде 10 Aql, где су линије Si I 6142.48 Å и 6155.13 Å асиметричне и померене. Аутори су прво израчунали параметре Штарковог ширења, користећи семикласични пертурбациони метод, за три спектралне линије неутралног силицијума: 5950.2 Å, 6142.48 Å и 6155.13 Å. Изменили су програм за рачунање синтетичког спектра тако да се узимају у обзир и Штаркове ширине и помаци за анализиране линије. На основу упоређивања теоријских прорачуна са посматрањима, нашли су да ефекти Штарковог ширења + хемијског раслојавања (стратификације) могу да објасне асиметрију Si I 6142.48 Å и 6155.13 Å линија.

За анализу, искористили су посматрања нормалне звезде HD32115, и две Ap звезде HD122970 и 10 Aql, као и Solar Flux Atlas [65]. CCD спектри високе резолуције 10 Aql и HD122970 су описани у раду Рјабчикова и др. [66]. CCD спектри високе резолуције (R приближно 45000) звезде HD32115 у опсегу таласних дужина 4000 -9500 Å добијени су помоћу coude-echell спектрометра монтираног на двометарски Цајсов телескоп на опсерваторији на врху Терскол у Русији (види Бикмаев и др. [67] за више детаља).

Велики број Ap звезда показује нерегуларне профиле линија Si I, али већина има јака магнетна поља која деформишу профиле линија преко Земановог цепања. Прилично слаба магнетна поља код Ap звезда HD122970 и 10 Aql, омогућују да се утицај магнетног поља на облик линије занемари.

Прорачун модела атмосфере, као и израчунавање коефицијента апсорпције, изведени су у апроксимацији локалне термодинамичке равнотеже (ЛТЕ). Рачунање модела атмосфере извршено је уз помоћ компјутерског програма ATLAS9 који је написао Р. Л. Куруц [68].

Следећи корак био је рачунање флукса ка посматрачу, у функцији (за одговарајућу мрежу тачака) таласне дужине, користећи дати модел. За то је узет компјутерски програм STARSP, који је написао В. В. Цимбал [69], и то измењена верзија, која израчунава синтетички спектар за атмосферу са вертикалним раслојавањем (стратификацијом) хемијских елемената.



СЛИКА 6. *Упоређивање профила спектралне линије 6155 Å неутралног силицијума, посматране у спектру Ap звезде 10 Aql (дебела линија) и синтетичког спектра израчунатог са Штарковом ширином и помаком из табеле 1 у реф. [54] и раслојавањем (стратификацијом) обилности силицијума (танка линија), са истим Штарковим параметрима али за хомогену расподелу силицијума (цртице), као и са Штарковом ширином узетом помоћу апроксимативне формуле за исто раслојавање силицијума (тачкаста линија).*

Прво су израчунали спектралне линије неутралног силицијума у спектру Сунца, да би проверили параметре Штарковог ширења и са поправљеним Штарковим параметрима синтетисали су профиле линија у спектрима звезда HD32115, HD122970 и 10 Aql.

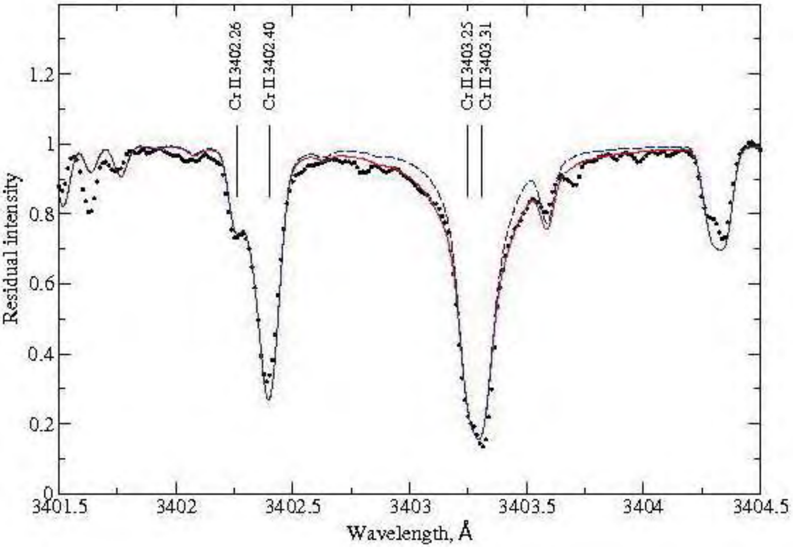
Звезда 10 Aql= HD176232 је најврелија у њиховом узорку. Има углавном асиметрични профил линије Si I 6155.13 Å, што се не може репродуковати ниједном комбинацијом параметара Штарковог ширења у хомогеној атмосфери. Чак и слабија, Si I 6142.48 Å линија, има значајан помак. Рјабчикова и др. [66] поменули су могућност раслојавања (стратификације) гвожђа и ретких земља у атмосфери 10 Aql. Они су покушали да нађу емпиријски, једноставну расподелу силицијума у 10 Aql, која би фитовала како Si I 6142.48 Å тако и 6155.13 Å линију. Добијена расподела даје разумно слагање посматраног и синтетисаног профила за обе силицијумове линије (Сл. 6). Штавише, чини се да иста расподела силицијума много боље фитује профиле јаких Si II 6347, 6371 Å спектралних линија, у поређењу са прорачунима са хомогеном Si обилношћу (-4.19), које су извели Рјабчикова и др. [66]. У својој анализи, аутори подвлаче, да са употребљеним параметрима

Штарковог ширења, осетљивост асиметрије 6155.13 Å линије на промене обилности Si у звезданој атмосфери, може бити успешно употребљена за емпиријска истраживања раслојавања обилности у атмосферама хладних Ap звезда.

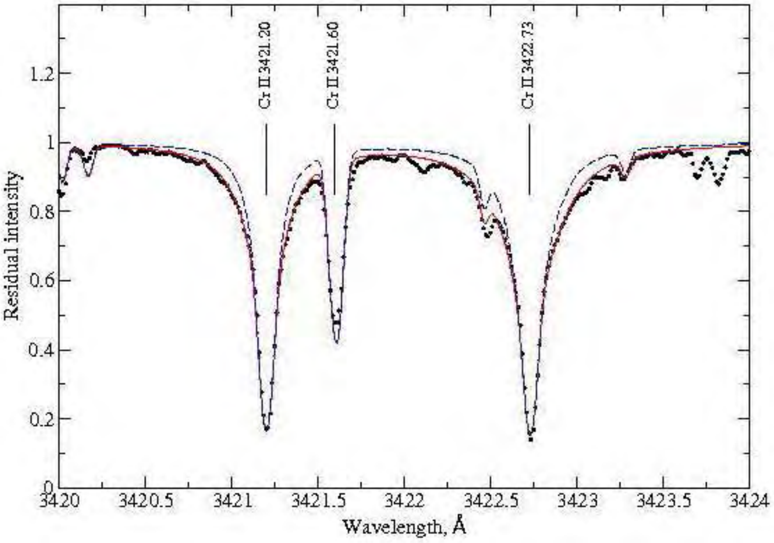
9. ШТАРКОВО ШИРЕЊЕ ЛИНИЈА ЈОНИЗОВАНОГ ХРОМА У СПЕКТРУ Ap ЗВЕЗДЕ HD 133792

Димитријевић и др. [70] су истраживали Cr II линије у спектру Ap звезде HD 133792, за које постоји пажљиво изведена анализа обилности и стратификације [71]. Звезда HD133792 има ефективну температуру T_{eff} = 9400 K, површинску гравитацију $\log g$ = 3.7, и средњу обилност хрома +2.6 dex у односу на обилност овог елемента код Сунца [71]. Сви прорачуни су изведени са побољшаном верзијом SYNTH3 компјутерског програма SYNTH за прорачун синтетичког спектра. Штаркови параметри пригушења су унети у компјутерски програм. Употребљена је раслојена (стратификована) расподела хрома у атмосфери HD133972, изведена у реф. [71]. На Сл. 7 је посматрани профил линије Cr II 3403.30 Å, упоређен са синтетичким са параметрима Штарковог ширења из рада Димитријевић и др. [70] и Куруцовим [72]. Добро слагање посматрања и прорачуна за неколко слабих Cr II линија, потврђује употребљену расподелу раслојавања хрома, док слагање за све четири јаке Cr II линије, демонстрира добру тачност добијених теоријских параметара Штарковог ширења у реф. [70].

То отвара нову могућност, да се теоријски и експериментални резултати о Штарковом ширењу додатно провере помоћу звезданих спектара, чему нарочито могу да допринесу развој спектроскопије помоћу уређаја у космосу, изградња џиновских телескопа нове генерације и пораст тачности и поузданости компјутерских програма за моделирање звезданих атмосфера. Линије Cr II анализиране у реф. [70] су нарочито погодне за такву сврху, пошто имају добра и чиста крила, где је утицај Штарковог ширења најважнији.



СЛИКА 7. *Поређњење посматраног (тачке) профила линије Cr II 3403.30 Å, и синтетисаног са параметрима Штарковог ширења из рада Димитријевић и др. [70] (пуна линија) и Куруцовим [72] (испрекидана линија).*



СЛИКА 8. *Исто као на Сл. 7, само за линије Cr II 3421.20, 3422.73 Å.*

10. МОДИФИКОВАНИ СЕМИЕМПИРИЈСКИ МЕТОД ЗА ШТАРКОВО ШИРЕЊЕ И АСТРОФИЗИЧКЕ ПРИМЕНЕ

Модификована семиемпиријска теорија (МСЕ) [73,74] за прорачун параметара Штарковог ширења изолованих спектралних линија неводоничних јона, успешно је примењена много пута за различите проблеме у астрофизици и физици. Према МСЕ прилазу [73-79], пуна ширина изоловане јонске линје на половини максималног интензитета (FHWM) услед судара са електронима је

$$w_{MSE} = N\frac{4\pi}{3c}\frac{\hbar^2}{m^2}\left(\frac{2m}{\pi kT}\right)^{1/2}\frac{\lambda^2}{3^{1/2}}\left[\sum_{l_i\pm1}\sum_{L_{i'}J_{i'}}\Re^2_{l_i,l_i\pm1}\tilde{g}(x_{l_i,l_i\pm1})+\sum_{l_f\pm1}\sum_{L_{f'}J_{f'}}\Re^2_{l_f,l_f\pm1}\tilde{g}(x_{l_f,l_f\pm1})\right.$$

$$\left.+\left(\sum_{i'}\Re^2_{ii'}\right)_{n\neq0}g(x_{n_i,n_i+1})+\left(\sum_{f'}\Re^2_{ff'}\right)_{n\neq0}g(x_{n_f,n_f+1})\right],$$

а одговарајући Штарков помак

$$d = N\frac{2\pi}{3c}\frac{\hbar^2}{m^2}\left(\frac{2m}{\pi kT}\right)^{1/2}\frac{\lambda^2}{3^{1/2}}\left[\sum_{L_{i'}J_{i'}}\sigma J_i J_{i'}\Re^2_{l_i,l_i\pm1}\tilde{g}_{sh}(x_{l_i,l_i\pm1})\right.$$

$$-\sum_{L_{i'}J_{i'}}\sigma J_i J_{i'}\Re^2_{l_i,l_i-1}\tilde{g}_{sh}(x_{l_i,l_i-1})\sum_{L_{f'}J_{f'}}\sigma J_f J_{f'}\Re^2_{l_f,l_f+1}\tilde{g}_{sh}(x_{l_f,l_f+1})$$

$$+\sum_{L_{f'}J_{f'}}\sigma J_f J_{f'}\Re^2_{l_f,l_f-1}\tilde{g}_{sh}(x_{l_f,l_f-1})+\left(\sum_{i'}\Re^2_{ii'}\right)_{\Delta n\neq0}g_{sh}\left(x_{n_i,n_i+1}\right)$$

$$-2\sum_{i'(\Delta E_{ii'}<0)}\sum_{L_{i'}J_{i'}}\Re^2_{l_i,l_{i'}}g_{sh}(x_{l_i,l_{i'}})-\left(\sum_{f'}\Re^2_{ff'}\right)_{\Delta n\neq0}g_{sh}\left(x_{n_f,n_f+1}\right)$$

$$\left.+2\sum_{f'(\Delta E_{ff'}<0)}\sum_{L_{f'}J_{f'}}\Re^2_{l_f,l_{f'}}g_{sh}(x_{l_f,l_{f'}})+\sum_k\delta_k\right],$$

где је почетни енергетски ниво означен са i, крајњи са f, а сума квадрата матричних елемената $\Re$ за разлику главних квантних бројева $\Delta n \neq 0$, је

$$\left(\sum_{k'}\Re^2_{kk'}\right)_{\Delta n\neq0}=\left(\frac{3n_k^*}{2Z}\right)^2\frac{1}{9}\left(n_k^{*2}+3l_k^2+3l_k+11\right)$$

у Кулоновој апроксимацији. При томе је

$$x_{l_k, l_{k'}} = \frac{E}{\Delta E_{l_k, l_{k'}}}, \qquad k = i, f,$$

где је $E=3kT/2$ кинетичка енергија електрона, а

$$\Delta E_{l_k, l_{k'}} = \left| E_{l_k} - E_{l_{k'}} \right|$$

$$x_{n_k, n_k+1} \approx \frac{E}{\Delta E_{n_k, n_k+1}}$$

а за $\Delta n \neq 0$ енергетска разлика између нивоа са n_k и n_k+1 је процењена као

$$\Delta E_{n_k, n_k+1} \approx \frac{2Z^2 E_H}{n_k^{*3}}$$

при чему је

$$n_k^* = \left(\frac{E_H Z^2}{E_{ion} - E_k} \right)^{1/2}$$

ефективни главни квантни број, Z резидуално наелектрисање јона, односно наелектрисање остатка које „види“ оптички електрон, то јест електрон који врши прелаз (Z=1 за неутралне атоме, 2 за једноструко наелектрисане јоне ...) и E_{ion} одговарајућа граница спектралне серије. N и T су електронска густина и температура, док су са $g(x)$ [80], $\tilde{g}(x)$ [73] и $g_{sh}(x)$ [80], $\tilde{g}_{sh}(x)$ [74] означени одговарајући Гаунт фактори за ширину и помак. Фактор

$$\sigma_{kk'} = \frac{E_{k'} - E_k}{\left| E_{k'} - E_k \right|},$$

где су E_k и $E_{k'}$ енергије разматраног нивоа и нивоа који га пертурбује. Сума по δ_k

$$\delta_i = \pm \Re_{ii'}^2 \left[g_{sh}\left(\frac{E}{\Delta E_{i,i'}} \right) \mp g_{sh}\left(x_{n_i, n_i+1} \right) \right]$$

$$\delta_f = \mp \Re_{ff'}^2 \left[g_{sh}\left(\frac{E}{\Delta E_{f,f'}} \right) \mp g_{sh}\left(x_{n_f, n_f+1} \right) \right],$$

је различита од нуле само за оне пертурбујуће нивое, ако постоје, за које су јако нарушене претпостављене апроксимације.

У поређењу са потпуним семикласичним [45-47], и Гримовим семиемпиријским прилазом [80], за који треба практично исти сет атомских података као и за најсофистициранији семикласични, за модификовани семиемпиријски метод [73-79] потребно је знатно мање таквих података. У ствари, ако нема нивоа за које су претпостављене апроксимације јако нарушене, за прорачун Штаркове ширине, потребни су само енергетски нивои са $\Delta n = 0$, пошто је допринос свих нивоа са $\Delta n \neq 0$, који су потребни за потпуни семикласични прорачун и Гримову семиемпиријску формулу, приближно збирно процењен.

Услед потребе за знатно мањим бројем атомских података у поређењу са потпуним семикласичним пертурбационим [45-47], и Гримовим семиемпиријским прилазом [80], MCE метод је посебно користан за звездану спектроскопију, за коју су потребни атомски подаци и подаци о параметрима ширења за веома обимну листу елемената и спектралних линија, при чему није могуће у свим случајевима од интереса применити софистициране теоријске методе.

MCE метод је такође веома користан када су потребни подаци за веома велики број спектралних линија, а није неопходна велика тачност за сваку појединачну линију, као што су то на пример прорачуни преноса зрачења или моделирање плазме. Осим тога, у случају комплекснијих атома или вишеструко наелектрисаних јона, услед недостатка тачних атомских података потребних за прецизније прорачуне, поузданост семикласичних резултата опада. У таквим случајевима, MCE метод може такође бити интересантан.

11. УПРОШЋЕНА МСЕ ФОРМУЛА

За астрофизичке потребе, од посебног интереса може бити упрошћена МСЕ формула [76] за Штарково ширење изолованих линија, једноструко и вишеструко наелектрисаних неводоничних јона, примењљива у случају када је ниво најближи горњем и доњем нивоу прелаза, на који је могућ диполно дозвољени прелаз са почетног (*i*) или крајњег (*f*) енергетског нивоа разматране линије, тако далеко да је услов

$$x_{jj'} = E / \left| E_{j'} - E_j \right| \leq 2$$

задовољен. У таквом случају, пуна ширина на половини максималног интензитета дата је изразом [76]:

$$W(\overset{\circ}{\mathrm{A}}) = 2.2151 \times 10^{-8} \frac{\lambda^2 (\mathrm{cm}) N (\mathrm{cm}^{-3})}{T^{1/2}\ (\mathrm{K})} \left(0.9 - \frac{1.1}{Z} \right) \sum_{\mathrm{j=i,f}} \left(\frac{3n_j^*}{2Z} \right)^2 \left(n_j^{*2} - l_j^2 - l - 1 \right)$$

Овде, $E = 3kT/2$ је енергија пертурбујућег електрона, *Z-1* је наелектрисање јона, а *n** ефективни главни квантни број. Ова формула је од интереса за одређивања обилности, као и за истраживања звезданих атмосфера. Пошто су услови важења често задовољени у условима звездане плазме.

Слично у случају помака

$$d(\overset{\circ}{\mathrm{A}}) = 1.1076 \times 10^{-8} \frac{\lambda^2 (cm) N (cm^{-3})}{T^{1/2}\ (K)} \frac{9}{4Z^2}$$
$$\times \sum_{j=i,f} \frac{n_j^{*2} \varepsilon_j}{2l_j + 1} \left\{ \left(l_j + 1 \right) \left[n_j^{*2} - \left(l_j + 1 \right)^2 \right] - l_n \left(n_j^{*2} - l_j^2 \right) \right\}$$

Ако сви нивои који улазе у горњу суму постоје, може се извести додатно сумирање и добија се

$$d(\overset{\circ}{\mathrm{A}}) = 1.1076 \times 10^{-8} \frac{\lambda^2 (cm) N (cm^{-3})}{T^{1/2}\ (K)} \left(0.9 - \frac{1.1}{Z} \right) \frac{9}{4Z^2}$$
$$\times \sum_{j=i,f} \frac{n_j^{*2} \varepsilon_j}{2l_j + 1} \left(n_j^{*2} - 3l_j^2 - 3l_j - 1 \right)$$

где је $\varepsilon = +1$ за $j = i$ и -1 за $j = f$.

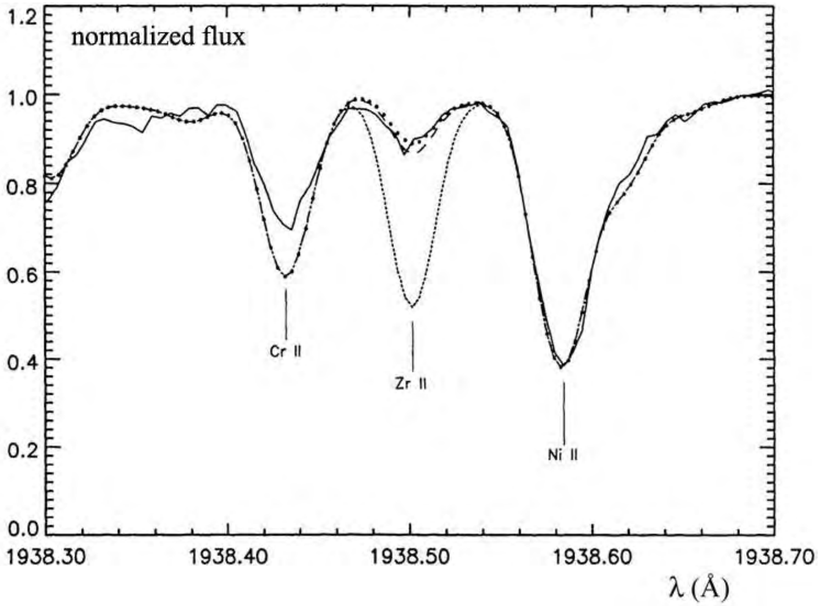
Модификовани семиемпиријски метод тестиран је више пута на бројним примерима [36]. Да би се проверио овај метод, експериментални подаци за 36 мултиплета (7 различитих врста јона) троструко наелектрисаних јона упоређени су са теоријским ширинама линије и добијени следећи усредњени односи мерених и теоријских вредности [73]: за двоструко наелектрисане јоне 1.06 ± 0.32 а за троструко наелектрисане 0.91 ± 0.42. Претпостављена тачност MCE формуле је око ±50%, али је показано [78,81,82] да чак и у случају емитера са веома комплексним спектрима (нпр. Xe II и Kr II), MCE метод даје веома добро слагање са експериментом (у интервалу ±30%). На пример за Xe II, 6s-6p прелазе, средњи однос између експерименталних и теоријских ширина линије је 1.15 ± 0.5 [81].

Израчунате су Штаркове ширине, а у неким случајевима и помаци, за спектралне линије следећих елемената: Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, Mn II, La II, Au II, Eu II, V II, Ti II, Kr II, Na II, Y II, Zr II, Sc II, Nd II, Be III, B III, S III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III, La III, V III, Ti III, Bi III, Sr III, Cu III, Co III, Cd III, B IV, Cu IV, Ge IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI, и Cl VI.

12. ПРИМЕНА НА ИСТРАЖИВАЊЕ „ЦИРКОНИЈУМСКОГ КОНФЛИКТА“ У АТМОСФЕРИ ЗВЕЗДЕ χ LUPI

Пример примене MCE формуле је разматрање „цирконијумског конфликта“ у атмосфери звезде χ Lupi [83]. Да би анализирали овај проблем, напоменимо да истраживања обилности за звезде раних типова показују да око 10% - 20% звезда A и B спектралног типа имају аномалије обилности, укључујући аномалије у изотопном саставу [83]. Аномалије обилности у овим звездама, које се зову CP звезде, проузроковане су различитим хидродинамичким процесима у спољашњим звезданим слојевима (који су потпомогнути и олакшани магнетним пољима, слабим звезданим ветровима, турбуленцијом, мешањем услед ротације итд.). Да би се истражили ови процеси, потребни су атомски подаци за много линија бројних емитера/апсорбера.

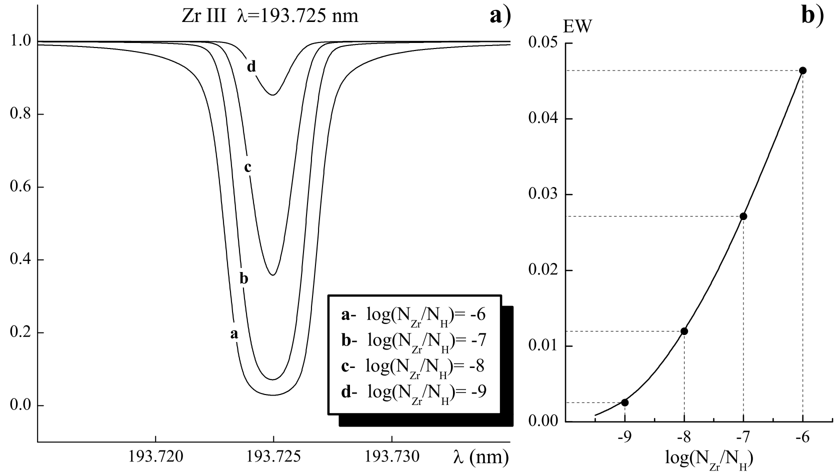
Линије цирконијума на пример, присутне су у спектрима HgMn звезда [26,84-86]. Занимљиво је да су обилности цирконијума одређене из слабих оптичких Zr II и јаких Zr III линија (које су откривене у UV) потпуно различите (види [26,86]) код HgMn звезде χ Lupi. Ово је илустровано на Сл. 9, на којој је приказан UV спектар ове звезде у опсегу таласних дужина 1938.3 - 1938.7 Å. Пуном линијом је означен спектар добијен помоћу GHRS. Тачкастом линијом је показана синтетисана Zr II 4d5s5p $^2D^o_{3/2}$ - $4d^25s$ $a^2D_{3/2}$ λ=1938.5 Å линија, добијена за обилност цирконијума log $[N_{Zr}/N_H]$=-8.12. Ова вредност обилности је добијена помоћу Zr III спектралних линија. Испрекиданом линијом је означен синтетизовани спектар за обилност цирконијума log $[N_{Zr}/N_H]$=-9.1, а са већим тачкама за log $[N_{Zr}/N_H]$=-9.0 [26]. То је такозвани „цирконијумски конфликт“ и Сикстрем и др. (Sikström) [86] су претпоставили да је ова разлика вероватно последица неадекватног коришћења модела звезданих атмосфера, на пример ако није узет у обзир утицај не-ЛТЕ ефеката или дифузије.



СЛИКА 9. *UV спектар звезде χ Lupi у 1938.3 Å – 1938.7 Å опсегу таласних дужина. Пуном линијом је означен спектар добијен помоћу GHRS. Тачкастом линијом је показана синтетисана Zr II 4d5s5p $^2D^o_{3/2}$ - $4d^25s$ $a^2D_{3/2}$ λ=1938.5 Å линија, добијена за обилност цирконијума log $[N_{Zr}/N_H]$=-8.12. Ова вредност обилности је добијена помоћу Zr III спектралних линија. Испрекиданом линијом је означен синтетизовани спектар за обилност цирконијума log $[N_{Zr}/N_H]$=-9.1, а са већим тачкама за log $[N_{Zr}/N_H]$=-9.0[26].*

Цирконијум, који у HgMn звездама често има много већу обилност него код Сунца (види [85]), је члан Sr-Y-Zr тријаде, која је веома битна за проучавање s-процеса нуклеосинтезе и указано је да представља не-нуклеарни образац обилности у HgMn звездама. Најочигледније објашњење ове аномалије је помоћу теорије дифузије, или укључивањем не-ЛТЕ ефеката. Ипак, од значаја је такође истраживање доприноса цирконијумском конфликту разлике параметара Штарковог ширења Zr II и Zr III спектралних линија.

Поповић и др. [83] су, користећи модификовану семиемпиријску формулу, одредили параметре Штарковог ширења услед судара са електронима за две астрофизички значајне Zr II и 34 Zr III спектралне линије, да би тестирали утицај овог механизма ширења линија на одређивање еквивалентних ширина и да би дискутовали његов могући утицај на одређивање обилности цирконијума.



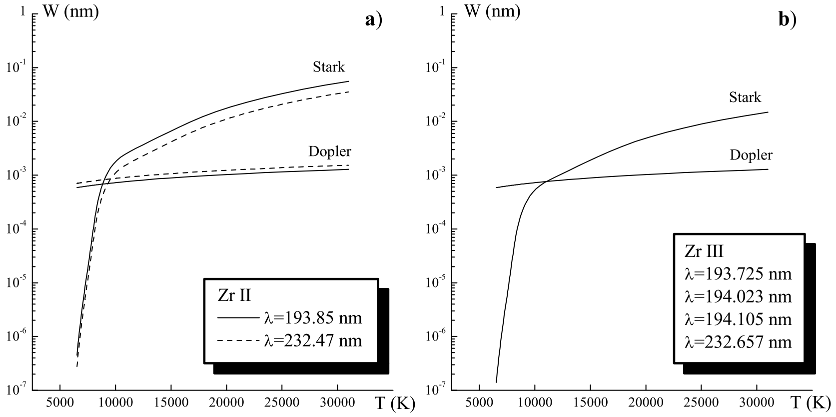
СЛИКА 10. *Промена профила линије Zr III* $4d^{2}\,{}^{3}P_{1}$ *-* $4d5p\ {}^{3}P^{o}_{0}$ *λ=1937.25 Å услед промене обилности цирконијума log* $[N_{Zr}/N_{H}]$ *за моделе звезданих атмосфера са* T_{eff}*=10500 K, log g=4.0 и турбулентном брзином* V_t*=0.0 km* s^{-1} *(a). На Сл. (b) је представљена еквивалентна ширина у функцији обилности цирконијума.*

Атомски енергетски нивои потребни за рачунање узети су из реф. [87,88]. Добијени резултати су употребљени да би се видело да ли ширење услед судара са електронима може да допринесе настанку такозваног „цирконијумског конфликта“ код HgMn звезде χ Lupi.

Да би се тестирао значај ефекта ширења спектралних линија услед судара са електронима за одређивање обилности цирконијума, Поповић и др. [83] су синтетисали профиле линија Zr II, λ=1938. Å и Zr III, λ=1940. Å, користећи компјутерски програм SYNTH [89] и Куруцов програм ATLAS9 за модел звездане атмосфере [72] са T_{eff}= 10500 K, log g = 4.0 и турбулентном брзином V_t=0.0 km s^{-1}, то јест за модел звездане атмосфере са карактеристикама сличним случају χ Lupi (T_{eff}=10650 K и log g=3.8, види Лекроне и др. (Leckrone) [90]).

Ове линије су изабране, зато што су биле уобичајено коришћене за одређивања обилности, пошто имају мали помак таласне дужине и добро су раздвојене [90]. Промена профила линије Zr III 4d^2 $^3P_1$ - 4d5p $^3P^o_0$ λ=1937.25 Å услед промене обилности цирконијума, представљена је на Сл. 10а, док је на Сл. 10б приказана еквивалентна ширина у функцији обилности цирконијума

Поповић и др. [83] су израчунали еквивалентне ширине са и без утицаја ширења сударима са електронима за различите обилности цирконијума. Добијени резултати за ZrIII [194.0 nm] и ZrII [193.8 nm] линије показују да је ефекат ширења електронима значајнији за веће обилности цирконијума. Еквивалентна ширина расте са обилношћу за обе линије, али еквивалентна ширина за ZrIII [194.0 nm] линију је осетљивија него за ZrII [193.8 nm]. То може довести до грешке у одређивању обилности у случају када ефекат ширења сударима са електронима није узет у обзир. У сваком случају, синтетисање ове две линије да би се одредила обилност цирконијума, без узимања у обзир ширине услед судара са електронима, довешће да је обилност цирконијума одређена помоћу ZrIII [194.0 nm] линије већа него ако се одреди користећи ZrII [193.8 nm] линију. Ипак, овај ефекат не може да изазове разлику у обилности од једног реда величине.



СЛИКА 11. *Понашање Штаркових и Доплерових ширина (FWHM) са температуром, за моделе звезданих атмосфера са* T_{eff}*=10500 K, log g=4.0 и* V_t*=0.0$ км* c^{-1} *за a) Zr II 4d5s5p* $^2D^o_{3/2}$ *- 4d*^{2}*5s a*$^2D_{3/2}$ *λ=193.85 nm (пуна линија) и Zr II 4d5s5p y*$^2F^o_{5/2}$ *- 4d*^{2}*5s b*$^2G_{7/2}$ *λ=232.47 nm (испрекидана линија), и b) Zr III 4d*^{2} $^3P_1$ *- 4d5p* $^3P^o_0$ *λ=193.725 nm, Zr III 4d*^{2} $^1G_4$ *- 4d5p* $^1F^o_3$ *λ=194.023 nm, Zr III 4d*^{2} $^3P_2$ *- 4d5p* $^3P^o_1$ *λ=194.105 nm и Zr III 4d*^{2} $^3P_1$ *- 4d5p* $^3P^o_1$ *λ=194.657 nm. На Сл. 11б није показана зависност од температуре за све наведене линије пошто је приближно једнака.*

Премда се „цирконијумски конфликт“ код HgMn звезде χ Lupi не може објаснити само овим ефектом, треба узети у обзир да занемаривање Штарковог ширења може да доведе до грешака у одређивању обилности. Штавише на Сл. 11 је показано да је Штарково ширење упоредиво са Доплеровим или доминантно за температуре око 10 000 K и веће.

13. РЕТКЕ ЗЕМЉЕ У СПЕКТРИМА CP ЗВЕЗДА

Други пример применљивости MCE метода у астрофизици је истраживање спектралних линија елемената ретких земаља (rare earth element - REE) у спектрима CP звезда. Спектроскопски подаци за елементе ретке земље (REE) су од интереса за астрофизику пошто су линије јонизованих REE присутне у звезданим спектрима. Штавише, обилност REE у CP звездама је у широком опсегу температура много већа него на Сунцу (види нпр. Рјабчикова и др. [91]), и атомски подаци за REE су потребни да би се решавали астрофизички проблеми као што су релативне обилности елемената који настају у r- и s-процесима у Хало звездама сиромашним металима и еволуција CP звезда [92,93]. Обично се анализа обилности REE заснива на линијама првог јонизационог стања, за које постоје експериментално одређене јачине осцилатора. У неким CP звездама, на пример код HD 101065 [91], присутан је велики вишак REE.

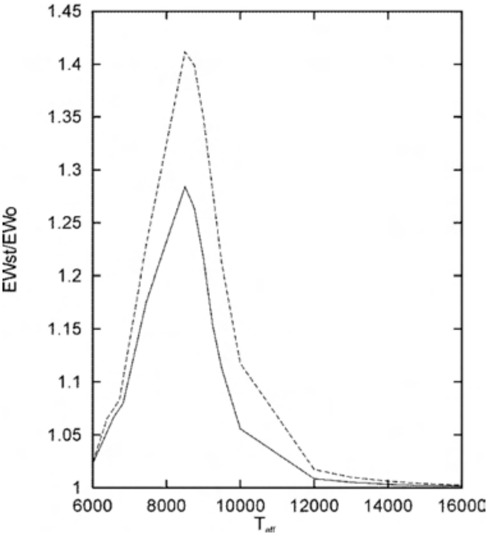
У Поповић и др. [91], израчунати су помоћу модификоване семиемпиријске формуле Штаркове ширине и помаци за шест линија Eu II и ширине за три La II и шест La III мултиплета. Помоћу добијених резултата истражен је утицај механизма ширења спектралних линија сударима са електронима у атмосферама топлих звезда. Показано је да је овај механизам ширења значајан у топлим звездама, и да треба да се узима у обзир код анализе звезданих спектралних линија за $T_{eff} > 7000$ K, посебно ако је обилност еуропијума велика.

У Поповић и др. [96], користећи MCE формулу, одређене су Штаркове ширине за 284 Nd II линије. Линије јонизованог неодимијума посматране су у спектрима CP, као и других звезда (види нпр. [94,97,98]). Услед услова у звезданим атмосферама, Nd II линије су доминантне у поређењу са Nd I и Nd III линијама. На пример у спектру roAp звезде HD101065, Каули и др. (Cowley) [94] су нашли 71 линију Nd II, а само 6 линија Nd I и 7 Nd III. Због тога се за одређивање обилности неодимијума код CP и других звезда, обично користе линије Nd II. Са друге стране, услед сложености Nd II спектра, веома је тешко добити атомске податке (јачине осцилатора, Штаркове ширине, итд.) потребне за астрофизичке сврхе.

Поповић и др. [96], су за прорачун Штаркове ширине користили упрошћени MCE прилаз Димитријевића и Коњевића [76]. Ова формула даје боље резултате него старија апроксимативна формула Каулија (Cowley) [99], често коришћена за процену Штаркове ширине када се не могу применити поузданији методи.

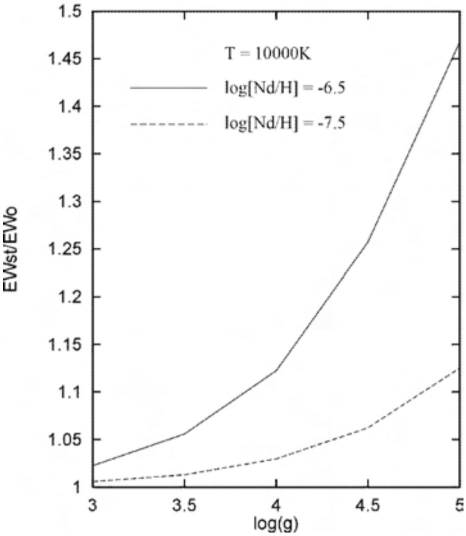
Да би тестирали значај ефекта ширења линија сударима са електронима у звезданим атмосферама, Поповић и др. [96] су синтетисали профиле 38 Nd II линија помоћу компјутерских програма за моделирање звезданих атмосфера SYNTH [89] и ATLAS9 [68], у температурском опсегу $6000 \leq T_{eff} \leq 16000$ K, и $3.0 \leq \log g \leq 5.0$.

Профиле линија су синтетисали са и без узимања у обзир Штарковог ширења сударима са електронима, за различите типове звезданих атмосфера. Прво су синтетисали све разматране профиле за обилност неодимијума A = log *[Nd/H]*=-7.0, и две вредности log g = 4.0 и 4.5 за различите ефективне температуре (T_{eff} = 6000 – 16000 K). Све разматране линије имају сличну зависност од ефективне температуре.



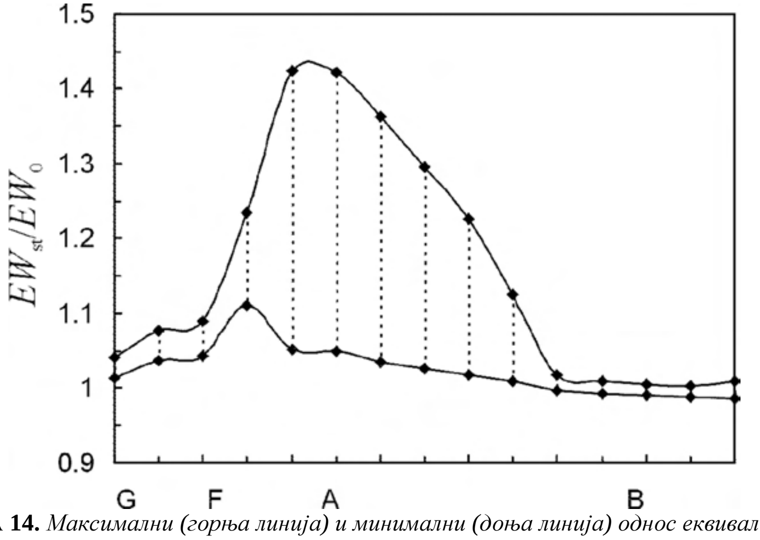
СЛИКА 12. *Однос еквивалентних ширина Nd II 4013.3 Å линије, израчунат са укључивањем Штарковог ширења (EW_{St}) и без њега (EW_0) у функцији ефективне температуре. Резултати за log g=4.0 и log g=4.5 приказани су пуном, односно испрекиданом линијом.*

Као пример, на Сл. 12 је показан однос еквивалентне ширине EW_{St}/EW_0 – као функција звездане температуре за линију Nd II 4013.3 Å. Као што се на слици може видети, највећи утицај ширења сударима са електронима на еквивалентну ширину је у опсегу ефективних



СЛИКА 13. *Однос еквивалентних ширина* EW_{St}/EW_0 *у функцији log g за Nd II 4062.2 Å спектралну линију, за две вредности обилности неодимијума.*

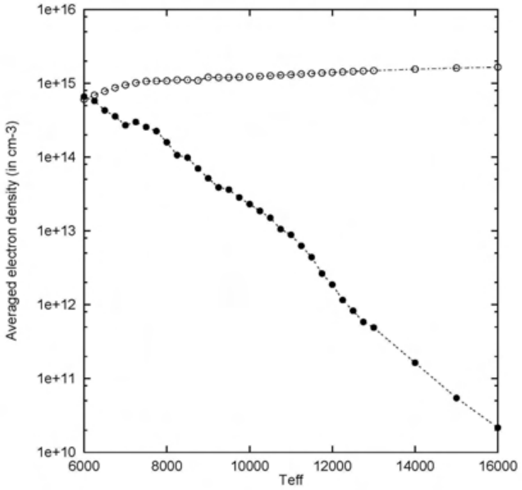
температура T_{eff} = 8000 K - 10000 K. Напоменимо да је вредност обилности неодимијума за Сунце -10.55, што је три реда величине мање



СЛИКА 14. *Максимални (горња линија) и минимални (доња линија) однос еквивалентних ширина* EW_{St}/EW_0 *за различите спектралне типове звезда, за 38 Nd II спектралних линија.*

од вредности коришћене на Сл. 12, тако да су Сунчеве Nd II линије слабе и релативно неосетљиве на ширину пригушења.

На Сл. 13, илустрована је зависност од површинске гравитације, утицаја ширења линија сударима са електронима на еквивалентне ширине, за линију Nd II λ = 4062.2 Å и log [Nd/H] = -6.5 и -7.5. Утицај је већи за веће обилности неодимијума, и расте са порастом површинске гравитације.



СЛИКА 15. *Средње електронске густине у атмосфери (празни кругови) и у слојевима где је густина неодимијумових јона највећа (T=7000 K – 9000 K, испуњени кругови), у функцији ефективне температуре која одговара спектралним типовима звезда од G до B.*

Да би указали на спектралне типове звезда где је ефекат ширења линија сударима са електронима најзначајнији, Поповић и др. [96] су дали преглед укупног утицаја у различитим типовима звезданих атмосфера, разматрајући најмањи и највећи утицај на све проучаване линије. Овај резултат је показан на Сл. 14, где је приказан однос еквивалентних ширина у функцији спектралног типа звезде. Као што се може видети на Сл. 14, највећи утицај механизма Штарковог ширења је код звезданих атмосфера A типа.

Узимајући у обзир да Штарково ширење зависи од електронске густине (N), ефекат је највећи у атмосферама врелих звезда код којих је електронска густина већа, пошто водоник постаје јонизован. Може се очекивати да ће утицај Штарковог ширења бити већи за топлије звезде, али с обзиром да јон Nd II настаје у делу звездане атмосфере са одговарајућим параметрима плазме, то није случај. Полазећи од чињенице да је потенцијал јонизације Nd II 10.73 eV, и да слојеви где је густина јона Nd II највећа имају електронску температуру између 7000 K и 9000 K, Поповић и др. [96] су израчунали средњу електронску густину у овим слојевима звездане атмосфере за различите спектралне типове звезда и log g = 4.0. Како се може видети на Сл. 15, средња електронска густина опада са ефективном температуром. То је разлог зашто је највећи утицај ефекта Штарковог ширења у случају Nd II, код звезданих атмосфера А типа.

14. СРПСКА ВИРТУАЛНА ОПСЕРВАТОРИЈА И БАЗА ПОДАТАКА STARK-B

Српска виртуална опсерваторија је нови пројекат чије је финансирање одобрило Министарство за науку и технолошки развој Србије преко пројекта TR13022. Циљеви пројекта су:

- установити SerVO и придружити се EuroVO (Европска виртуална опсерваторија) и IVOA (International Virtual Observatory Alliance – Међународни савез виртуалних опсерваторија);
- установити SerVO центар података за дигитализацију и архивирање астрономских података добијених на Астрономској опсерваторији у Београду;
- развој алата за визуализацију података.

Главни циљ је да се публикују у VO компатибилном формату, подаци које су добили српски астрономи, као и да се астрономима у Србији обезбеде VO алати за научни рад. У прве три године главни циљеви пројекта су:

- дигитализција и публиковање у виртуалној опсерваторији фотографских плоча из архива Астрономске опсерваторије;
- публиковање, заједно са Париском опсерваторијом, базе података о Штарковом ширењу STARK-B, која ће, као први корак, садржати параметре Штарковог ширења, које су Димитријевић и Саал-Брешо добили у оквиру семикласичног пертурбационог прилаза током тридесетогодишње сарадње, у VO компатибилном формату;
- прављење мирор сајта за DSED (Darthmouth Stellar Evolution Database) у VO контексту.

У базу података STARK-B, улазе управо подаци о Штарковом ширењу о којима смо говорили у овом раду. Напоменимо да је претходник SerVO била BELDATA а њен главни садржај била је база података о Штарковом ширењу спектралних линија. Историја BELDATA може се следити у [100-104]. После интензивирања сарадње са француским колегама око базе података MOLAT на Париској опсерваторији, BELDATA је постала STARK-B.

Ова база података намењена је моделизацији и спектроскопској дијагностици звезданих атмосфера и омотача. Такође је од користи и за истраживања лабораторијске плазме, ласерски произведене плазме, инерцијалне фузије, као и за развој ласера и плазмене технологије.

Сходно томе опсег температура и густина који покривају табеле је широк и зависи од степена јонизације разматраног јона. Температура варира од неколико хиљада за неутралне атоме до неколико милиона Келвина за високо наелектрисане јоне. Електронска или јонска густина мења се од 10^{12} (случај звезданих атмосфера) до неколико пута 10^{23} cm^{-3} (субфотосферски слојеви и истраживања инерцијалне фузије).

Обезбеђена је проста графичка међувеза (интерфејс) са подацима (види http://stark-b.obspm.fr/elements.php). Корисник прво бира елемент из периодичног система који га интересује. После тога јонизационо стање, пертурбер(е), густину пертурбера, прелаз и температуру плазме, после чега се генерише табела са описом података, пуном ширином линије на половини максималног интензитета и помаком линије. Планирана су два мирор сајта, један у Медону и један у Београду.

Даљи развој ће бити да излазни подаци буду усаглашени са ВО стандардима (који тек треба да буду у потпуности дефинисани), као и да се база потхрани са још елемената /јонизационих стања. Ова база података улази и у европски ФП7 пројекта Виртуални центар за атомске и молекуларне податке (Virtual Atomic and Molecular Data Centre - VAMDC) први ФП7 пројекат у српској астрономији – чији конзорцијум чини 15 установа из 9 земаља. Његов циљ је да изгради доступну и интероперабилну е-инфраструктуру за атомске и молекуларне податке, проширујући и интегришући замашан број база података, за потребе различитих корисника у науци и индустрији.

15. ЗАКЉУЧАК

Као што се из изложеног може закључити, мултидисциплинарна област истраживања Штарковог ширења спектралних линија плазме у Србији има критичну масу и омогућава младима да се баве науком на светском нивоу и своје радове пласирају у врхунске међународне часописе. Оваква истраживања у астрономији имају и своју конференцију у Србији. I-III Југословенска конференција о облицима спектралних линија одржане су 1995,1997 и 1999, у Криваји код Бачке Тополе, Белој Цркви и Бранковцу на Фрушкој Гори, IV Српска конференција о облицима спектралних линија у Аранђеловцу 2003, а V-VII Српска конференција о облицима спектралних линија у астрофизици 2005, 2007 и 2009, у Вршцу, Сремским Карловцима и Зрењанину.

ЗАХВАЛНОСТ

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Collisions of emitters and absorbers with charged particles and stellar plasma

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Abstract. Collisions of emitters and absorbers with charged particles influence on spectral line shapes of stellar plasma, since due to splitting and shifting of atomic energy levels in electric field (Stark effect) lines in spectra are broadened and shifted. In this work is analyzed the importance of Stark broadening of such lines for analysis, interpretation and synthesis of stellar spectra, analysis, diagnostics and modelling of stellar plasma, and the significance of such results for investigations of laboratory, fusion and technological plasmas, as well as for the physics of lasers. It is considered for which types of stars and for which investigations Stark broadening is significant, and methods for theoretical determination of Stark broadening parameters of spectral lines are discussed. A review of such investigations on the Belgrade Astronomical Observatory is given as well.

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ABSTRACT BOOK

Romanian-Serbian Collaboration in Astronomy

Milan S. Dimitrijevic, Magda Stavinschi

Abstract:

In this contribution we present and analyze the collaboration of Romanian and Serbian astronomers, from the time on collaboration on the reform of Julian calendar. We also analyze the data on mutual visits of Romanian and Serbian astronomers, obtained by perusing the Guest Book of Bucharest Astronomical Observatory and Annual Reports of Directors of Belgrade Astronomical Observatory published in various editions, as well as the history of four common meetings of Romanian and Serbian astronomers (Timisoara, Belgrade, Cluj-Napoca, Belgrade) organized by us.

Page 8

Rigas Velestinlis and Astronomy in His Anthology of Physics (For 250 Years from His Birthday)

Efstratios Theodossiou, Vasilis N. Manimanis, Milan S. Dimitrijevic, Emmanouel Danezis

Abstract:

Rigas Velestinlis (Velestino 1757 - Belgrade 1798) was a herald and martyr of freedom, but also one of the forerunners of the modern Greek enlightenment movement. With his restless intellectual researches, his books and publications, and his revolutionary ideas, he managed to participate in the intellectual awakening of his enslaved nation, channeling through his works the novel ideas of the European enlightenment together with the messages of French revolution. His vision was a great revolution, uprising of enslaved nations against Ottoman repression, which will result in the creation of a democratic community of nations of Balkans and neighbouring areas. An important part of his life he lived in Bucharest and tragically died in Belgrade, so that he is important for Romanian and Serbian history, too. For the history of astronomy, interesting is his Anthology of Physics, where astronomical contents are present. In this contribution, his life and work are presented and analyzed, with a particular attention to the astronomical aspects of the mentioned work.

Page 13

Stark Broadening of O V 1371 A Line in Stellar Atmospheres

Milan S. Dimitrijevic, Andjelka Kovacevic, Zoran Simic, Miodrag Dacic

Abstract:

The Stark broadening of O V 1371 A spectral line observed in stellar atmospheres of hot stars is considered. The corresponding Stark broadening parameters were determined within the semiclassical

method. We found that Stark broadening mechanism is very important in atmospheres of hot stars like DO white dwarfs and should be taken into account.

Page 41-42

Electron-Impact Broadening of Ar I 737.212 nm Spectral Line for Stellar Atmospheres Research

Milan S. Dimitrijevic, Magdalena Christova, Zoran Simic, Sylvie Sahal-Brechot

Abstract:

With the development of space-born spectroscopy, the importance of atomic data, including the Stark broadening parameters, for trace elements like argon, increases. For example argon is found in CVn binary σ^2 Coronae Borealis, and recently, argon lines are observed in the optical spectrum of the Be star Hen 2-90. Also argon abundance has been determined from spectral lines, e.g. for LSE 78, an extreme helium star, for the similar star BD-9-4395, for DY Cen and *γ* Peg. Consequently, electron-impact (Stark) line-broadening parameters for neutral and ionized argon are of interest for the modelling and investigation of astrophysical plasmas. Here are determined needed Stark broadening parameters (width and shift) for Ar I 737.212 nm spectral lines on the basis of the impact theory within the semi-classical perturbation approach.

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Romanian-Serbian collaboration in Astronomy

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Abstract.
In this contribution we present and analyze the collaboration of Romanian and Serbian astronomers. We also give the data on mutual visits of Romanian and Serbian astronomers, obtained by investigating the Guest book of Bucharest Astronomical Observatory and Annual Reports of Directors of Belgrade Astronomical Observatory published in various editions, as well as the history of four common meetings of Romanian and Serbian astronomers (Timisoara, Belgrade, Cluj-Napoca, Belgrade) organized by authors of this contribution.

Keywords: history of astronomy, Romanian astronomy, Serbian astronomy, Belgrade Astronomical Observatory, Bucharest Astronomical Observatory
PACS: 01.65.+g, 95.45.+i, 95.55.-n

INTRODUCTION

We analyze here the inscriptions of Serbian astronomers in the Guest book of Bucharest Astronomical Observatory, as well as the reports on mutual visits in Annual Reports of Directors of Belgrade Astronomical Observatory, Milan Nedeljković, Vojislav Mišković, Milorad Protić, Pero Djurković, and the Report of Božidar Popović, Secretary in the time of Director Milutin Milanković published in various editions, as well as the history of four common meetings of Romanian and Serbian astronomers (Timisoara 1995, Belgrade 1996, Cluj-Napoca 1997, Belgrade 1998) organized by authors of this contribution, in order to give a review of Romanian Serbian contacts and collaboration in astronomy.

FIRST CONTACTS AND EXCHANGE OF VISITS

First mutual visits of Serbian and Romanian astronomers, registered in reports on activity of Belgrade Astronomical Observatory are the 6 days visit of Pero Djurković, Director of Belgrade Observatory, to Bucharest Observatory in October 1967, and the 9 days visit of Nicolae Dinulescu to Belgrade in the same year [1]. Visit of Pero Djurković is also registered in the Guest book of Bucharest Observatory (Fig. 1). It is obvious that Pero Djurković, as director of Belgrade observatory (1965-1970), wanted to establish collaboration and regular exchange of visits with Romanian astronomers.

Consequently, in 1968, in Bucharest were [1] Dragomir Olević 30 days and Djordje Teleki 12 days and in Belgrade were Ludmila Rusu 27 days, Constantin Dramba 9 days and Victor Stavinschi 10 days. In Guest book exist the inscription signed by Dragutin

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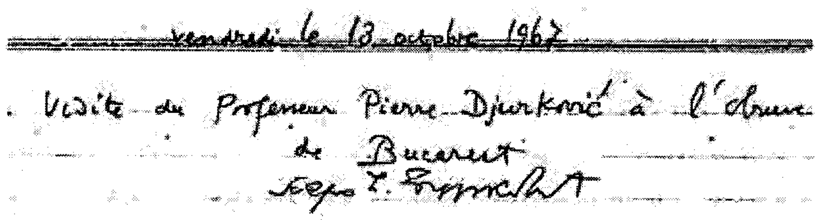

vendredi le 13 octobre 1967

Visite du Professeur Pierre Djurković à l'Observ. de Bucarest

Pero M. Djurković

FIGURE 1. Inscription of Pero Djurković in the Guest book of Bucharest Observatory: *Friday, 13 October 1967 Visit of Professor Pierre Djurković to the Bucharest Observatory Pero M. Djurković*

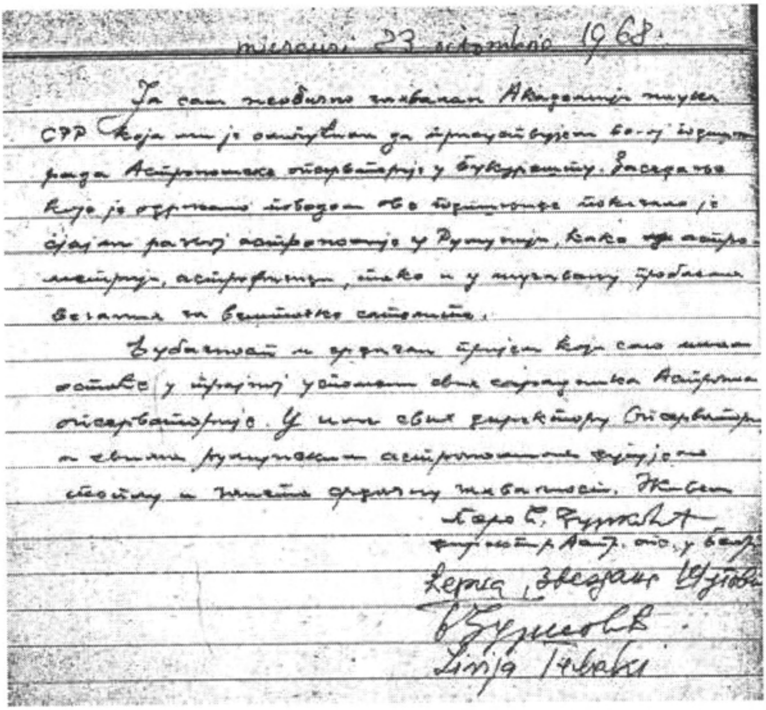
Djurović from the Department of Astronomy of the Belgrade Faculty of Sciences, his wife Leposava Djurović, his son Milan and Dragomir Olević [2]. Also here is the inscription of 23 October 1968, signed by Pero Djurković, his daughter Zvezdana Šugović, his wife Branka Djurković and the wife of Djordje Teleki, Livija Teleki. This is a testimony that Pero Djurković included in this exchange of visits and Department of Astronomy of the Belgrade Faculty of Sciences, and that Serbian astronomers were on these visits often with their families, which shows the particularly friendly character of established collaboration. It is also interesting that the visit of October 1968 was on the occasion of the celebration of 60th anniversary of the Bucharest observatory, and the corresponding inscription in the guest book is given with translation in Fig. 2.

In the 1969, Djurović [1] reported 20 days visits of Ljubiša Mitić and Ivan Pakvor to Bucharest Observatory and their inscriptions in the Guest book are present as well. In 1970 Djurković finished his duty of Director and it is obviously that with the end of his directorship ended any initiative for further collaboration, since after this we have an emptiness of 26 years without any inscription of Serbian astronomers in the Guest book of Bucharest Astronomical Observatory.

RENEWAL OF CONTACTS AND ORGANIZATION OF COMMON MEETINGS

When was appointed to the duty of Director of Belgrade Astronomical Observatory, in November 1994, M. S. Dimitrijević, wishing to establish the collaboration of Serbian astronomers with neighboring countries, wrote a letter to M. Stavinschi with the proposition to exchange visits and to sign an agreement of collaboration of two institutions. M. Stavinschi invited him to Bucharest, and the Agreement on collaboration was signed on 12th May 1995, during his visit. It is worth to note that this Agreement is still valid and it enabled a number of visits through Romanian and Serbian Academies of Sciences. They also agreed to organize a round table of Romanian and Serbian astronomers on collaboration, and to organize one each year in order to get to know their work and facilitate the collaboration.

The First Romanian-Serbian round table on cooperation in Astronomy was organized after two months, on 20th July 1995 in Timisoara. From Serbia attended Jelisaveta Arsenijević, Zorica Cvetković, Miodrag Dačić, Milan S. Dimitrijević, Slobodan Jankov,



miercuri 23 octombrie 1968.

FIGURE 2. Inscription in the Guest book of the Bucharest Observatory: *I am exceptionally grateful to Romanian Academy of Sciences who enabled me to attend to the celebration of 60 years of Astronomical Observatory in Bucharest. Session on the occasion of this Anniversary showed excellent development of Astronomy in Romania, as in Astrometry and Astrophysics, as well in the investigation of Earth's artificial satellites. Hospitality and warm reception we had will stay forever in the memory of all. I express my sincere gratitude to the Director of Observatory and to all Romanian astronomers. Cheerio!*
Pero Djurković
Director of the Belgrade Astronomical Observatory
daughter Zvezdana Šugović
B. Djurković
Livija Teleki

Darko Jevremović, Luka Č. Popović and Ištvan Vince [3]. The Second Yugoslav-Romanian round table on cooperation in astronomy was held in Belgrade on 8th October 1996, before the XI National Conference of Yugoslav Astronomers (Belgrade, 9-11.10.1996) so that Romanian guests may attend the both. Participants were [4]: Magdalena Stavinschi, Petre Popescu, Lucian Burs, Laslo Farkas, Alexandru Horvat, Georgeta Maris, Olga Atanacković-Vukmanović, Zorica Cvetković, Miodrag Dačić, Milan S. Dimitrijević, Gojko Djurašević, Zoran Knežević, Jelena Milogradov-Turin, Dragomir Olević, Luka Č. Popović, Vojislava Protić-Benišek, Veselka Trajkovska and Ištvan Vince.

The Third Romanian-Yugoslav round table on cooperation in Astronomy was organized in Cluj-Napoca on 6th September 1997, after 3rd General Conference of the Balkan

FIGURE 3. II Yugoslav-Romanian round table on cooperation in Astronomy, Belgrade 8 X 1996. Milan S. Dimitrijević, Magda Stavinschi, Alexandru Horvat, Vojislava Protić-Benišek, GojkoDjurašević

FIGURE 4. II Yugoslav-Romanian round table on cooperation in Astronomy, Belgrade 8 X 1996. Standing Petre Popescu, Lucian Burs, Zoran Knežević, Veselka Trajkovska, Luka Č. Popović, Dragomir Olević, Laslo Farkas, Zorica Cvetković, Olga Atanacković-Vukmanović, Gojko Djurašević, Aleksandru Horvat, Miodrag Dačić, Ištvan Vince. Front row: Jelena Milogradov-Turin, Milan S. Dimitrijević, Magda Stavinschi, Vojislava Protić-Benišek

Physical Union (Cluj-Napoca, 2-5.09.1997). From Serbia attended [5] Zorica Cvetković, Milan S. Dimitrijević, Slobodan Ninković, Luka Č. Popović, Veselka Trajkovska and

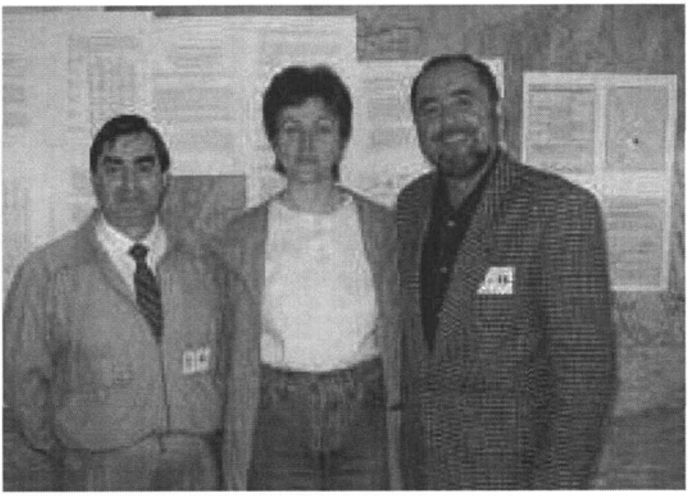


FIGURE 5. IV Romanian-Yugoslav Astronomical Meeting, Belgrade 5-8 May 1998. Miodrag Dačić, Zorica Cvetković, Petre Popescu

FIGURE 6. Participants of the IV Romanian-Yugoslav Astronomical Meeting, Belgrade 5-8 May 1998. First row: Edi Bon, Ištvan Vince, Radomir Petrović, Sanja Erkapić, Miodrag Dačić, Dragomir Olević. Second row: Radomir Djordjević, Nataša Popović, Jelena Milogradov Turin, Milan S. Dimitrijević, Magda Stavinschi, Georgeta Maris, Katalin Barlai, Dragana Tankosić, Aleksandar Kubičela. Behind: Vesna Živkov, Dan Moldovan, Milorad Djokić, Predrag Jovanović, Vasile Mioc, Petre Popescu, Aleksandar Tomić, Zorica Cvetković, Slobodan Ninković, Luka Č. Popović, Zoran Knežević, Cristina Blaga, Adrian Cristea, Božidar D. Jovanović, Vlado Milićević, Snežana Marković-Kršljanin, Milutin Tadić

FIGURE 7. IV Romanian-Yugoslav Astronomical Meeting, Belgrade 5-8 May 1998. Katalin Barlai, Cristina Blaga, Georgeta Maris, Vasile Mioc

Ištvan Vince.

The Fourth Yugoslav-Romanian Astronomical Meeting was organized as a Conference and held from 5 to 8 May 1998 in Belgrade. List of participants [7] has 57 names, and from Romania attended [6] Magdalena Stavinschi, Vasile Mioc, Petre Popescu, Georgeta Maris, Cristina Blaga, Adrian Cristea, Dan Moldovan, Alexandru Horvat and Laslo Farkas. Conference Proceedings [7] have 245 pages and sections were Astrophysics (19 papers), Astrometry (7 papers), Celestial Mechanics (6), Total Solar Eclipse on August 11 1999 (3), and Astronomy in Archaeology, History and Culture (17), totally 52 papers.

These meetings of Romanian and Serbian astronomers enabled that we know now each other, our work and activities. They also initiated mutual collaboration and were important for the latter organization of Balkan Astronomical Conferences. We hope that with this series of meetings we contributed to the collaboration of Romanian and Serbian astronomers and to the development of mutual relations of astronomers in Balkan and South Eastern Europe.

These meetings of Romanian and Serbian astronomers enabled that we know now each other, our work and activities. They also initiated mutual collaboration and were important for the latter organization of Balkan Astronomical Conferences. We hope that with this series of meetings we contributed to the collaboration of Romanian and Serbian astronomers and to the development of mutual relations of astronomers in Balkan and South Eastern Europe.

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Electron-impact broadening of Ar I 737.212 nm spectral line for stellar atmospheres research

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Abstract. Stark broadening parameters (width and shift) for Ar I 737.212 nm spectral line have been determined within the semiclassical perturbation theory for the stellar plasma conditions.

Keywords: stars: - A type, chemically peculiar - line profiles - atomic processes
PACS: 32.70.Jz; 95.30.Dr; 97.20.Ge

INTRODUCTION

Development of space-borne spectroscopy influenced on the increase of the importance of atomic data for trace elements like argon, including the Stark broadening parameters. For example, spectral lines of this element are observed in CVn binary σ^2 Coronae Borealis [1], and found in "Chandra's" X-ray spectra of young supernovas 1998S and 2003bo [2]. Also, argon abundance has been determined for several stars from the corresponding spectral lines, as for example for LSE 78, an extreme helium star [3], where Stark broadening is of interest, as well as for the similar star BD-9^{o}4395 [4]. We note here that particularly significant are lines within the optical spectral range and we have investigated recently Stark broadening of six just such lines of neutral argon (522.1, 549.6, 518.6, 603.2, 560.7 and 696.5 nm corresponding to the transitions $3p^5nd$ - $3p^54p$ for n = 7-5 and 4p' - 4s)[5].

Here are determined needed Stark broadening parameters (width and shift) for Ar I 737.212 nm spectral line on the basis of the impact theory within the semi-classical perturbation approach.

RESULTS AND DISCUSSION

Calculations have been performed within the semiclassical perturbation formalism [6, 7]. This formalism, as well as the corresponding computer code, have been optimized and updated several times. Details of updates and of calculations are given in [5]. The values of energy levels, which enter in the expressions of the semi-classical cross-sections, have been taken from NIST database [8]

Our results for electron-, and proton-impact line widths and shifts for the Ar I 737.212 nm spectral line, corresponding to the transition $4p[5/2]_3$-$4d[7/2]^o_4$, for a perturber den-

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TABLE 1. Electron-, and proton-impact broadening parameters for Ar I 737.212 nm spectral line, for a perturber density of 10^{16} cm^{-3} and temperatures from 2,500 up to 50,000 K. Quantity C is given in Å cm^{-3} and divided by the corresponding full width at half maximum (FWHM), gives an estimate for the maximum perturber density for which tabulated data may be used. The asterisk identifies cases for which the collision volume multiplied by the perturber density lies between 0.1 and 0.5.

Transition	T[K]	We[Å]	de[Å]	Wp[Å]	dp[Å]
ArI	2500.	0.572	0.367	*0.171	*0.787E-01
4p[5/2]$_3$-4d[7/2]$^o_4$	5000.	0.646	0.425	*0.182	*0.980E-01
737.212 nm	10000.	0.739	0.428	0.193	0.117
C= 0.65E+19	20000.	0.871	0.371	0.205	0.136
	30000.	0.964	0.318	0.213	0.148
	50000.	1.07	0.275	0.224	0.163

sity of 10^{16} cm^{-3} and temperatures T = 2,500 – 50,000 K are shown in Table 1.

The obtained results will be analyzed in detail and compared with experimental data elsewhere. With the previous results [5] are completed Stark broadening data for the spectral series 4p[5/2]$_3$-nd[7/2]$^o_4$ for the principal quantum number n from 4 to 7, enabling investigations of the corresponding systematic trend. We performed such analysis, and obtained a regular increase of the Stark width within the considered spectral series.

ACKNOWLEDGMENTS

This work is supported by the Technical University-Sofia, Bulgaria and project 146 001 "Influence of collisional processes on astrophysical plasma line shapes" supported by the Ministry of Science of Serbia.

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Stark broadening of O V 1371 Å line in stellar atmospheres

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Abstract. The Stark broadening parameters of O V 1371 Å spectral line, observed in stellar atmospheres of hot stars, determined within the semiclassical perturbation method, are used for the analysis of the importance of this broadening mechanism in white dwarf atmospheres. We found that Stark broadening mechanism is very important in such plasma conditions and should be taken into account.

Keywords: stars: - white dwarf - line profiles - atomic processes
PACS: 97.60.-s; 32.70.Jz; 95.30.Dr

INTRODUCTION

Due to the high cosmical abundance of oxygen, and presence of its different ionisation stages in stellar atmospheres, its astrophysical interest is obvious. Stark broadening parameters of O V spectral lines are of particular interest for the study of DB, DAO and DO white dwarfs, especially for PG 1159 type stars. They have been calculated in detail within the semiclassical perturbation approach by Dimitrijević and Sahal-Bréchot [1, 2].

Recently, Rauch et al. [3] underlined the need for Stark broadening parameters for O V $1s^2 2s2p\ ^1P^o{}_1$ - $1s^2 2p^2\ ^1D_2$ 1371 Å spectral line, as a strategic line for white dwarf spectra analysis and synthesis. For example, Jahn et al. [4] observed this line in the HST spectrum of PG 1159-035 star, Shipman et al. [5] in the intermediate - temperature DO white dwarf PG 1034+001 and, Holberg et al. [6] in photospheres of H-rich DA white dwarfs WD 0232+035, WD 0441+467, WD 0501+527, WD 0621-376, WD 1202+608, WD 2214+495, and He-rich DB and DO white dwarfs WD 0501+289, WD 1034+001, and WD 1159-034. Stark widths for this line are determined within the semiclassical perturbation theory [7, 8] for the electron density of 10^{20}cm^{-3} and electron temperatures from 80000 K up to 300000 K [9].

Since the corresponding range of plasma parameters is not adequate for a convenient analysis of stellar spectra, the objective of our work is to make a new determination of Stark broadening parameters for this spectral line and to use them for the analysis of the influence of Stark broadening mechanism on O V 1371 Å line in white dwarf atmospheres.

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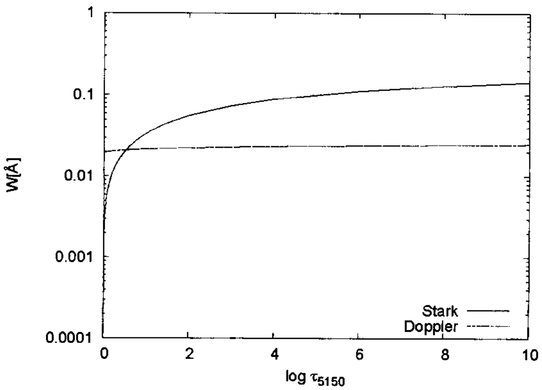

FIGURE 1. Thermal Doppler and Stark widths for O V spectral line (λ=1371.0 Å) for a DB white dwarf atmosphere model with T_{eff} = 25,000 K and log g = 9, as a function of optical depth τ_{5150}.

RESULTS AND DISCUSSION

The calculations of Stark broadening parameters have been performed within the semi-classical perturbation approach [7, 8]. The obtained results are used here to analyse the influence of the Stark broadening on O V spectral line for DB white dwarf plasma condition by using the corresponding model with T_{eff} = 25,000 K and log g = 9 [10]. As one can see in Fig. 1, for the considered DB white dwarf atmosphere model, thermal Doppler broadening has much less importance in comparison with the Stark broadening mechanism.

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Rigas Velestinlis and Astronomy in his "Anthology of Physics"

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Abstract. Rigas Velestinlis (Velestino 1757 - Belgrade 1798), Greek national hero of fight against Turkish Empire and one of the forerunners of the Greek enlightenment movement, an important part of his life lived in Bucharest and tragically died in Belgrade, so that he is important and for Romanian and Serbian history. For the history of astronomy, interesting is his *Anthology of Physics*, where astronomical contents are present. In this contribution, his life and work are presented and analyzed, with a particular attention to the astronomical aspects of the mentioned work and his connections with Romania.

Keywords: History of astronomy, Rigas Velestinlis
PACS: 01.65.+g, 01.60.+q

Rigas took the surname Velestinlis after the town of Velestino, Thessaly, where he was born in 1757. Velestino is located near the ancient city of Ferrae, so that Rigas is named often as "Ferraios". After the Treaty of Kuchuk-Kainarji (1774) he came first to Istanbul and later to Bucharest, where the Greek enlightenment and language where present.

Rigas had the thirst for learning, and the ambition to reach the level of the highest circles of his environment. In Bucharest, he served in the Court of the Greek Sovereign (voivoda) of Vlahia Nikolaos Karadjas (1782-1783).

In 1790, at the age of 33, Rigas obtained the possibility to stay for six months in Vienna as an interpreter and secretary of Christodoulos Kirlianos, a "Grand Serdaris". Rigas had already written and translated some of his many works, and there he started to print them (in more details in [1]).

Among them is a popularized manual of natural history and astronomy, *Anthology of Physics* (1790), presenting facts taken from French and German reference books on astronomy and physics with the personal style of Rigas. The motto in this book: "Whoever thinks freely, thinks good", characterized him since then.

In the preface is said that he does not attempt to show his knowledge or literary elements. He writes simply, in the language of the people, so that "everybody could understand it and could obtain a small idea of the incomprehensible physics". With this book he wanted to excite in the minds of the Greeks the curiosity and the interest in the scientific achievements of the enlightened Europe, believing that Enlightenment will push the enslaved Greek nation towards the liberty, and to eliminate superstitious beliefs (e.g. about comets). In the footsteps of Socrate and Galileo, he uses the form of a dialogue between a kind of student and him.

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He attempts to offer a general idea of the immensity of the Universe with its innumerable "suns"; his student understands this and he exclaims in amazement: "My God, how many suns, how many worlds!" Moreover, Velestinlis tries to communicate a general idea about the motions in the Solar System, since he mentions Ptolemy and his geocentric system, and on the other side the heliocentric system, mentioning Galileo and Copernicus - but also the ancient Greek philosophers who preceded them, such as Philolaos, Iketas and, of course, Aristarchus of Samos.

Concerning the possibility of life on other planets he writes: "If we accept the hypothesis that God did not create anything without a purpose, the planets must be related to a purpose and a reason. Why do you think they were created? And we do not see any other reason so informative than to consider them inhabited. Moreover, we conclude that, since they are habitable, they were created with this in mind and their inhabitants possess [an unexpected conclusion] a similar nature and intellect with ours."

Knowing the high or low temperatures of the other planets and the large differences in the conditions prevailing there as compared to the terrestrial ones, he extracts his own simple conclusions: "The inhabitants of Mercury and Saturn should be very dissimilar in nature; for the former planet has so excessive heat that causes the boiling of water, while on the latter the summer is so cold that it could be compared with the most horrible winter."

As for the Sun, Rigas knows that its nature is different from a fire burning on Earth. Moreover, in his book he cites the hypotheses of his epoch on the nature of light and solar energy.

In August 1796 Rigas is again in Vienna, since he has many manuscripts to print. First of all, a series of maps: The great Chart[er] of Greece, a map of Wallachia (1797), a map of Moldavia (1797).

In October 1797, he printed in hurry his revolutionary manifest, preparing his travel to Turkish-occupied Greece. The boxes with the revolutionary manifest were sent to Trieste, where Rigas himself arrived on 8 December 1797. However, the boxes had been seized by the Austrian authorities. As Turkish citizens, Rigas and his seven co-patriots were delivered to Osman pasha, the Ottoman governor of Belgrade on 10th of May. They were imprisoned in the Nebojsha tower of Belgrade, next to the Danube River, where on 13th (24th according to Gregorian calendar) of June 1798 they were executed by strangulation.

Rigas became (and remains) a symbol, a hero who fought and sacrificed himself for both national and human ideals. Moreover, the study of his works promoted him as the pioneer of the modern Greek Enlightenment, a thinker and visionary whose credo can be summarized in his superb motto: "Whoever thinks freely, thinks good".

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Gas Temperature Determination in Argon-Helium Plasma at Atmospheric Pressure using van der Waals Broadening

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Abstract. The use of the van der Waals broadening of Ar atomic lines to determine the gas temperature in Ar-He plasmas, taking into account both argon and helium atoms as perturbers, has been analyzed. The values of the gas temperature inferred from this broadening have been compared with those obtained from the spectra of the OH molecular species in the discharge.

Keywords: microwave discharges, argon, helium, van der Waals broadening, gas temperature.
PACS: 32.70.Jz (Line shapes, widths, and shifts), 52.20.Hv (Atomic, molecular, ion, and heavy-particle collisions), 52.70.Kz (Optical (ultraviolet, visible, infrared) measurements).

INTRODUCTION

In the last years, a common characteristic of most of the technological applications of plasmas is that they are a gas mixture. When more than one kind of gas is present in the discharge, the complexity of experimental determination of plasma parameters by spectroscopic techniques increases. It is due to the existence of different types of perturbers in the plasma gas, which have influence on the spectral line profiles and van der Waals broadening is a function of the reduced mass of colliding atoms. Studies of such influences are important for the application of spectroscopic techniques in the diagnostics of plasmas generated with gas mixtures.

Theoretically, any spectral line could be used for the determination of the plasma gas temperature from its van der Waals broadening. However, experimental studies carried out by several authors (see Ref. 1 and references therein) have stated that only a few lines can be used for this purpose. First of all, the separation of the van der Waals broadening from the whole width of the spectral profile, needs a deconvolution process. Also, the theory does not describe equally good the van der Waals broadening for each spectral line and for each kind of perturbers, so that the corresponding investigations in order to find the most convenient lines for this purpose are of interest.

In a surface wave plasma generated with pure Ar the contribution of the Stark broadening to the Lorentzian width for Ar lines belonging to the nd−4p transitions (4

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≤ n ≤ 7) has been studied [2]. The procedure used to separate both Lorentzian and Gaussian parts by these authors was the same as one used in the present work. Their results showed that Stark broadening can be considered negligible for the 737.2 nm (n = 4) line and very small for the 603.2 nm (n = 5). Consequently, they considered that the Lorentzian width of these lines was mainly due to the van der Waals effect and the gas temperature obtained from 603.2 nm was approximately equal to the one obtained from OH radical band (approximately 1500 K) in this case.

A method has been proposed [3] to measure the gas temperature (T_g) from atomic lines whose Stark broadening is comparable with the van der Waals one. The gas temperature was obtained from the origin ordinate corresponding to the Lorentzian width for zero electron density which could be considered approximately equal to van der Waals line broadening. For this study the best argon atomic lines for T_g calculation in an argon microwave plasma at atmospheric pressure were 603.2, 549.6 and 522.1 nm. The values obtained from this method were between 1100 and 1200 K. On the other hand, the Stark broadening of the 425.9 nm line has been studied [4]. By extrapolating these results to their experimental conditions, Yubero *et al.* [3] obtained that the van der Waals broadening of the above mentioned line was about 90% of the total Lorentzian width and the gas temperature from the van der Waals broadening of this line was equal to 1380 K. Consequently with all these results, the use of 425.9, 603.2, 549.6 and 522.1 nm lines to measure the gas temperature in plasmas generated with Ar-He mixtures was considered in the present work.

GAS TEMPERATURE DETERMINATION IN AR-HE MIXTURE DISCHARGE

The experimental procedure is described in detail in Ref 1. The spectra for these lines were registered in different conditions of Ar-He mixtures, observing a significant decrease of the intensities of the Ar atomic lines when He is added to the plasma gas. An analysis of the profiles of these lines was carried out in the more extreme condition which corresponded, in our case, to a 30% of He in the mixture. We found that with the increase of the upper level of the transition a high dispersion in the fit of the 549.6 nm ($4p$–$6d$ transition) and 522.1 nm ($4p$–$7d$ transition) line profiles to a Voigt function appears. Thus, only the 425.9 nm ($4s$–$5p$) and 603.2 nm ($4p$–$5d$) lines have been considered for this study.

The T_g values obtained from the van der Waals of the 603.2 and 425.9 nm lines appear depicted in Figures 1a and 1b, respectively. In the case of an Ar-He mixed gas discharge, full width at half maximum (FWHM) provoked by van der Waals broadening (w_W) is given by the following equations[1]

$$w_W(425.9\ \text{nm}) = \chi_{Ar}\frac{1.479}{T_g^{0.7}} + \chi_{He}\frac{1.059}{T_g^{0.7}} \qquad (1)$$

$$w_W(603.2\ \text{nm}) = \chi_{Ar}\frac{4.217}{T_g^{0.7}} + \chi_{He}\frac{3.019}{T_g^{0.7}} \qquad (2)$$

where χ_{Ar} and χ_{He} are molar fractions of the constituting gases, argon and helium. Also, the values obtained from OH radical band have been represented. In Figure 1 one observes that the T_g values calculated from w_W are a slightly higher that those obtained from OH radical. It is also observed a bigger dispersion in T_g values from w_W of 425.9 nm line than 603.2 nm line because of its smaller Lorentzian width value w_L, which results in higher error in the deconvolution process.

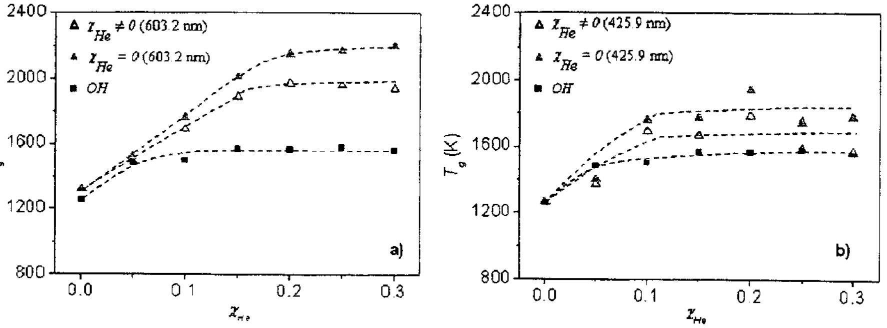

FIGURE 1. Gas temperature calculated using the (0−0) 309 nm ro-vibrational band of the OH radical and the 603▷2 nm (a) and 425▷9 nm (b) atomic argon lines taking into account (hollow triangle) and neglecting (full triangle) the contribution of He to the van der Waals broadening

Moreover, to point up that T_g values obtained from OH radical is lower than those obtained from the Lorentzian width of Ar lines for He concentrations above 5%. This can be due to a lack of sensitivity of the OH radical for temperatures higher than 1600−1800 K. This result seems to indicate that the best line for this purpose is the 603.2 nm according to the results found by Christova *et al.* [2] in plasmas generated with pure Ar. Besides, these study also shows the necessity to take into account the He contribution to the van der Waals broadening for lines used in Ar-He mixtures. This allows us to conclude that the above equations may be used when the van der Waals broadening of the considered argon lines is utilized for measuring the gas temperature in an Ar-He plasma.

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Using line broadening to determine the electron density in an argon surface-wave discharge at atmospheric pressure

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Abstract. Broadening due to collisions with charged particles (Stark broadening) and neutral atoms, was determined for Ar I 522.1, 549.6 and 603.2 nm spectral lines from the spectral series $3p^5nd$-$3p^54p$, in order to evaluate the electron density in a surface-wave discharge at atmospheric pressure.

Keywords: Line broadening, collisional broadening, plasma diagnostics, electron density
PACS: 32.60.+i; 32.70.Jz; 52.20.Fs; 52.20.Hv

INTRODUCTION

Pressure broadening of spectral lines is important for the diagnostics and modeling of laboratory plasmas, and for many purposes in astrophysics, as for example opacity calculations, abundance determination and analysis and synthesis of stellar spectra. Neutral atom broadening is more important for cooler stars like our Sun and Stark broadening for hot stars like A-type stars and in particular for DO and DB white dwarfs..

It is well known that argon is one of the most widely used gases in various fields of science and technology. On the other hand, with the development of space-borne spectroscopy, the importance of atomic data, including line broadening parameters for trace elements like argon [1], is increasing. Spectral lines within the optical spectral range are of particular interest.

In this work, different line broadening models are applied to three Ar I spectral lines to evaluate the electron density in a surface-wave discharge at atmospheric pressure. This method is useful in cases where the classical methods using hydrogen lines for electron density diagnostic cannot be applied.

THEORETICAL CALCULATIONS

Under atmospheric pressure conditions, the broadening mechanisms of spectral lines are: Stark broadening (due to collisions with charged particles), neutral atom collision broadening (due to collisions with neutral atoms), Doppler broadening and natural broadening. Natural broadening is negligible in comparison with other broadenings and

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broadening due to self-absorption can be avoided by a proper choice of the spectral lines. For both pressure-induced mechanisms of line broadening (Stark broadening and neutral atom broadening), the impact approximation theory has been applied.

Stark broadening

In this work, the Stark broadening has been calculated using Sahal-Bréchot theory [2, 3]. Within the semi-classical perturbation formalism, used in this theory, the full half width (W) of an isolated line originating from the transition between the initial level i and the final level f is expressed as:

$$W = 2n_e \int_0^\infty v f(v) dv [\Sigma_{i' \neq i} \sigma_{ii'}(v) + \Sigma_{f' \neq f} \sigma_{ff'}(v) + \sigma_{el}] \tag{1}$$

where i' and f' are perturbing levels, n_e and v are the electron density and the velocity of perturbers respectively, and $f(v)$ is the Maxwellian distribution of electron velocities. The inelastic collisional cross sections $\sigma_{ii'}(v)$ (respectively $\sigma_{ff'}(v)$) and the corresponding elastic collision contribution σ_{el} to the W are described in detail in [2, 3].

Broadening by neutral atom collisions

The line broadening by collisions with neutral atoms has been treated using the semi-classical theory calling for the impact approximation where the full width at half intensity maximum γ is given by:

$$\gamma = 2N < \sigma' v > = \beta N \tag{2}$$

where N is the perturber density, σ' is the effective cross section for the impact broadening of the line and β is the broadening coefficient. Here the symbols <...> denote the (thermal) average over a Maxwellian distribution of the relative velocities of the interacting atoms. Kaulakys potential [4] for the interaction between an emitting atom and rare-gas atoms has been used. This potential accounts for the polarization attractions between the emitter and perturber and for the short-range interactions between excited electrons of the emitter and perturber. The contributions from the polarization attraction of this potential are given by:

$$V\left(\vec{R},\vec{r}\right) = V_c\left(\vec{R}\right) + V_{ce}\left(\vec{R},\vec{r}\right) + V_e\left(\vec{r}-\vec{R}\right), |\vec{R}-\vec{r}| > r_0 \tag{3}$$

where $\vec{R}$ is the distance between the interacting atoms, $\vec{r}$ is the location of the excited electron and r_0 is the distance of the short-range interaction. The short-range interaction is approximated by the Fermi pseudo-potential:

$$V_e\left(\vec{r}-\vec{R}\right) = 2\pi L \delta\left(\vec{r}-\vec{R}\right) \tag{4}$$

where L is the scattering length.

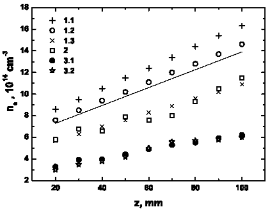

FIGURE 1. Axial variation (z - the position on the axis) of the electron density (n_e) obtained from different Ar I lines. Results obtained using the theory of Sahal-Bréchot for Stark broadening [2, 3] and the potential of Kaulakys [4] for neutral atom impact broadening: 1.1 - Ar I 522 nm; 1.2 - Ar I 549 nm; 1.3 - Ar I 603 nm. Results obtained with Stark broadening data of Griem [6] and van der Waals potential: 2 - Ar I 549 nm. Results obtained with data for Stark broadening of Hβ line from Griem [6] and Gigosos [7]: 3.1 - Hβ (Griem); 3.2 - Hβ (Gigosos).

RESULTS

Results for the axial variation of the electron density of surface-wave tubular discharges from the line broadening of three argon neutral lines are presented on the same figure. The examined argon lines Ar I 522.1, 549.6 and 603.2 nm are from the spectral series $3p^5nd$-$3p^54p$. The results are compared with those obtained in [5] from Ar I 549.6 nm and with the electron density values from the Stark broadening of hydrogen line H_β, using Griem's theory [6] and using Gigosos et al. model [7]. The calculations presented are of interest for determining the electron density of, for example, surface-wave discharges at atmospheric pressure using the line broadening of the carrier gas itself, therefore avoiding the use of hydrogenic spectral lines that imply perturbing the discharge to be diagnosed.

ACKNOWLEDGMENTS

M. Christova thanks to the Organizing Committee for the financial support to participate in the ICSLS Valladolid, June 2008. This work was partially financed by the Technical University - Sofia. This is also a part of the project 146001 of the Ministry of Science and Technological Development of Serbia.

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Similarity Between DACs/SACs Phenomena in Hot Emission Stars and Quasars Absorption Lines

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Abstract. In the spectra of Hot Emission Stars and AGNs we observe some peculiar profiles that result from dynamical processes such as accretion and/or ejection of matter from these objects. In this paper we indicate that DACs and SACs phenomena, can explain the spectral lines peculiarity in Hot Emission Stars and AGNs. We also try to connect the physical properties of absorption regions around stars and quasars.

Keywords: Hot Emission Stars, AGNs, Quasars, DACs, SACs
PACS: 97.10.Ex, 97.10.Fy, 97.10.Gz, 97.20.Ec, 97.30.Eh, 98.54.Aj

INTRODUCTION

The spectra of Hot Emission Stars and AGNs present peculiar profiles that result from dynamical processes such as accretion and/or ejection of matter from these objects. In the UV spectra of hot emission stars and AGNs the absorption lines have DACs or SACs that are shifted to the blue. In the case of hot emission stars, DACs or SACs arise from spherical density regions around the star, or from density regions far away from the star that present spherical (or apparent spherical) symmetry around their own center [1, 2, 3].

Similar phenomena can be detected in the spectra of AGNs. Wind (jets, ejection of matter etc.), BLR (Broad Line Regions) and NLR (Narrow Line Regions) are, probably, the density regions that construct these profiles of the spectral lines [3]. In order to study the observed peculiar profiles in the spectra of hot emission stars and AGNs, we use the GR model [4]. With this model we can reproduce the spectral lines complex profiles.

In this paper we indicate that DACs and SACs phenomena, can explain the spectral lines peculiarity in Hot Emission Stars and AGNs [5]. We also try to connect the physical properties of absorption regions around stars and quasars.

RESULTS AND DISCUSSION

Here we applied the GR model [2, 4] in order to fit stellar and quasar absorption lines (see Figures 1-3). In both cases we can find blue-shifted components, which are indicating an outflow (wind) in both objects. Difference is in the velocities, i.e. naturally

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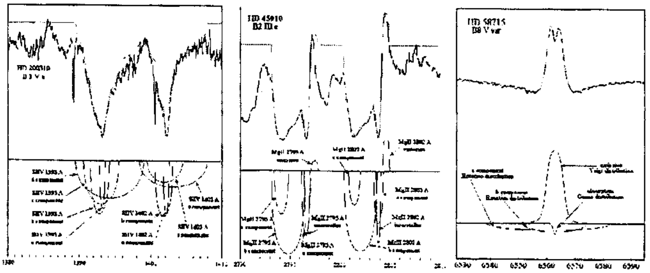

FIGURE 1. Best fit of the Si IV, Mg II and Hα spectral lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs.

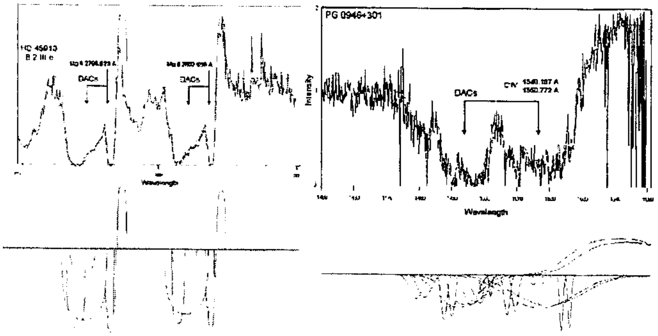

FIGURE 2. DACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the GR model fit one can see the analysis of the observed profile to its DACs or SACs.

the outflow velocities in quasars are higher ($\sim$ several 1000 km/s). But, the line profiles (as e.g. P-Cyg profile) in both objects are similar, indicating that natural phenomena are similar, but with different physical properties.

As we can see in Figure 2 (right) we can detect the DACs phenomenon in the spectra of some AGNs constructing complex profiles.

The presence of DACs phenomenon in the spectra of some AGNs lead us to search also for SACs in these spectra.

In Figure 3 (right) using the GR model we can see that the complex structure of many AGNs spectral lines can be explained with SACs phenomenon.

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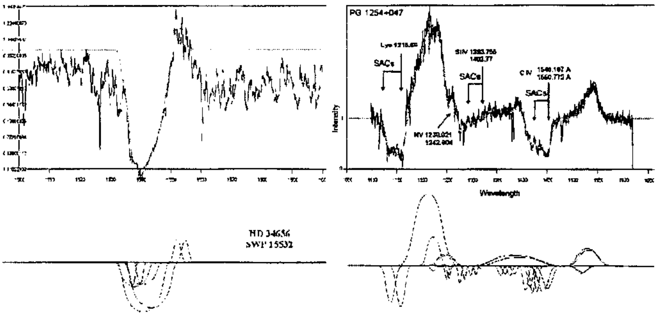

FIGURE 3. SACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the GR model fit one can see the analysis of the observed profile to its SACs.

astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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AX Mon (HD 45910) Kinematical Parameters in the Fe II Spectral Lines as a Function of the Excitation Potential

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Abstract. In the UV spectrum of AX Mon (HD 45910) we observe a series of spectral lines with complex structure and peculiar profiles. This peculiarity is due to SACs or DACs. In this paper, using the GR model, we study the complex profile of Fe II spectral lines and we calculate the relation of some kinematical parameters of the regions that create the DACs/SACs with the excitation potential.

Keywords: stars: Be, HD 45910; stars: line profiles - absorption components, DACs, SACs
PACS: 97.10.Ex, 97.10.Fy, 97.10.Kc, 97.20.Ec, 97.30.Eh

INTRODUCTION

AX Monocerotis (HD 45910=BD+5°, 1267=SAO 13974, a=6^h 27^m 52^s, δ=+5°, 54′,1 (1950), V=6,59-6,88 mag) is a binary system [1], consisting of a B2e III star and a some what fainter K0 III star, with an orbital period of 232.5 days [2, 3] and a variable spectrum [4, 5].

Danezis et al. [6, 7, 8] studied the UV spectrum of the system at phase 0.568 and detected the existence of two satellite components at the violet side and one at the red side of the main absorption lines, indicating that the envelope consists of four independent layers of matter. In the Fe II region they found three levels of values of radial velocities. The first level has values about -10 km/s, the second level has values about -72 km/s and the third level has values about -250 km/s.

Danezis et al. [9, 10] proposed the so called Gaussian-Rotational (GR) model. By applying this model we calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM) and the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines.

In this paper we apply the above mentioned model and calculate the radial, rotational and random velocities for a group of Fe II lines with values of excitation potential between 0.35 to 3.75 eV.

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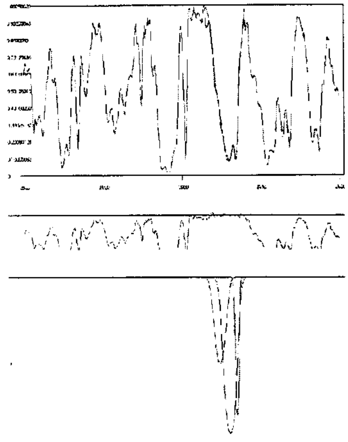

FIGURE 1. Best fit of the λ 2607.086 Å Fe II spectral line. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs.

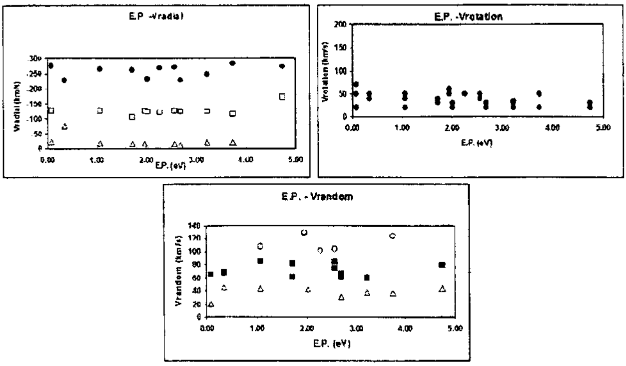

FIGURE 2. Radial (up, left), rotational (up, right) and random velocities (down) of the studied group of Fe II spectral line as a function of the excitation potential.

RESULTS AND DISCUSSION

In Figure 1, we give as an example the fit of the λ 2607.086 Å Fe II spectral line. We can see that the observed complex structure can be explained with SACs phenomenon.

In Figure 2 we present the variation of the radial, rotational and the random velocities of the studied group of Fe II lines as a function of the excitation potential. As we can see we detected three levels of radial velocities (up-left). The first level has values about -260 km/s (circle), the second one has values about -125 km/s (open square) and the third one has values about -18 km/s (triangle). These values are in agreement with the respective values found by Danezis et al. [8]. The values of the rotational velocities (Figure 2 up-right) for all SAC are between 20 and 60 km/s. Finally we detected three levels of the random velocities of the ions (Figure 2 down). The first level has values about 115 km/s (open circle), the second one has values about 70 km/s (square) and the third one has values of 35 km/s (triangle).

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A Study of the Structure of Different Ionization Potential Regions in the Atmosphere of AX Mon (HD 45910)

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Abstract. The complex structure and the peculiar profiles of some spectral lines are common in the UV spectrum of AX Mon (HD 45910). The observed peculiar profiles are composed by a number of SACs or DACs. In this paper, using the GR model, we study the complex profile of the Al II (λ 1670.81 Å), Al III (λλ 1854.722, 1867.782 Å), Mg II (λλ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II (λλ 1334.515, 1335.684 Å) and Si IV (λλ 1393.73, 1402.73 Å) spectral lines. Additionally, we calculate the relation of some kinematical parameters of the regions that create the DACs/SACs of the studied lines with the ionization potential.

Keywords: stars: Be, HD 45910; stars: line profiles - absorption components, DACs, SACs
PACS: 97.10.Ex, 97.10.Fy, 97.10.Kc, 97.20.Ec, 97.30.Eh

INTRODUCTION

AX Monocerotis (HD 45910) is a binary system [1], consisting of a B2e III star and a some what fainter K0 III star, with an orbital period of 232.5 days [2, 3] and a variable spectrum [4, 5].

Danezis et al. [6] presented a study of the variation of radial velocities and of the blue edge width. In this paper, using the Gaussian-Rotational (GR) model [7, 8] we calculate the radial, rotational and random velocities in the Al II (λ 1670.81 Å), Al III (λλ 1854.722, 1867.782 Å), Mg II (λλ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II (λλ 1334.515, 1335.684 Å) and Si IV (λλ 1393.73, 1402.73 Å) spectral lines of AX Mon, as a function of the ionization potential.

RESULTS AND DISCUSSION

In Figure 1 using the GR model we can see that the complex structure of the λλ 1854.722, 1862.782 Å Al III (left) and λλ 2795.523, 2802.698 Å absorption and emission Mg II (right) resonance spectral lines can be explained with SACs and DACs phenomenon.

In Figure 2 we present the variation of the radial, rotational and the random velocities in the Al II (λ 1670.81 Å), Al III (λλ) 1854.722, 1867.782 Å), Mg II (λλ 2795.523,

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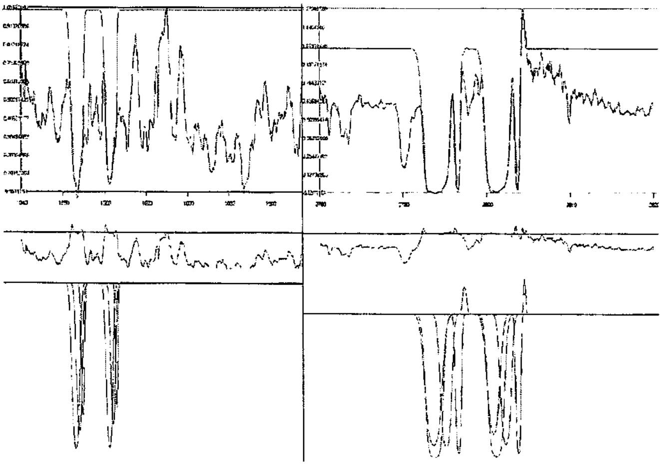

FIGURE 1. Best fit of the λλ 1854.722, 1862.782 Å Al III (left) and λλ 2795.523, 2802.698 Å absorption and emission Mg II (right) resonance spectral lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis (GR model) of the observed profile to its SACs or DACs.

2802.698 Å), Fe II (λ 2586.876 Å) C II (λλ 1334.515, 1335.684 Å) and Si IV (λλ 1393.73, 1402.73 Å) spectral lines as a function of the ionization potential.

As we can see, we detected four levels of radial velocities (up-left). The first level has values about -260 km/s and corresponds to ionization potential larger than 20 eV. The second level has values about -140 km/s, the third one has values about -35 km/s and the fourth one has values about 119 km/s. All these values correspond to ionization potential with values between 0 and 10 eV. The values of the rotational velocities (Figure 2 up-right) are between 150 and 450 km/s and correspond to ionization potential larger than 10 eV. The low values of the rotational velocities (10-50 km/s) correspond to ionization potential with values between 0 and 10 eV. Finally, we also detected four levels of the random velocities of the ions (Figure 2 down). The first level has values about 108 km/s and corresponds to ionization potential larger than 18 eV. The second level has values about 80 km/s, the third one has values about 47 km/s and the fourth one has values about 22 km/s. All these values correspond to ionization potential with values between 0 and 10 eV.

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This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science of Serbia, through the projects “Influence of collisional processes on astrophysical plasma line shapes” and “Astrophysical spectroscopy of extragalactic objects”.

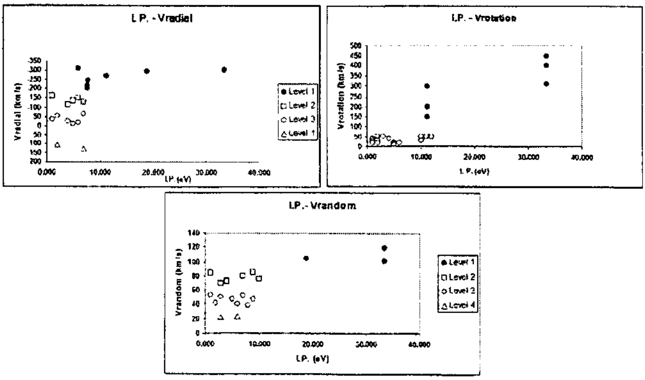

FIGURE 2. Radial (up, left), rotational (up, right) and random velocities (down) in the atmosphere of AXMon (HD 45910) spectral lines as a function of the ionization potential.

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Kinematics of Broad Absorption Line Regions of PG 1254+047

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Abstract. In this paper we study the Lyα spectral line and the N V, Si IV and C IV resonance lines in the UV spectrum of the Broad Absorption Line Quasar (BAL QSO) PG 1254+047. We found that the studied Broad Absorption Lines (BALs) of this quasar are created by a number of Satellite Absorption Components (SACs). We calculated some kinematical parameters such as the apparent rotational (Vrot) and radial (Vrad) velocities of the regions where the studied lines are created and the random velocities (Vrand) of the studied ions.

Keywords: Quasars: BALQSOs, PG 1254+047, DACs, SACs
PACS: 98.54.Aj

INTRODUCTION

In a number of quasars (about 10-20%), blue-shifted, broad absorption lines (BALs) are observed in the ultraviolet spectra. These lines are formed in partially ionized outflows with velocities up to 0.1 c. The outflow is likely driven by intensive radiation of the quasar probably along the equatorial directions to the extension at least larger than the broad emission line region (BLR). Disk wind and material evaporating from the putative dust torus are two plausible scenarios for the origin of the gas. In order to understand the nature of outflow in quasars, we need to explore many properties of the outflow such as the global covering factor of BAL region, the column density and velocity fields.

Here we investigate the physical properties of Broad Absorption Line Regions (BALRs) of quasar PG 1254+047 using a model (previously developed for stellar absorption line modelling) proposed by Danezis et al. [1] (GR model). With this model one can accurately fit the observed complex profiles of both emission and absorption spectral lines. With this model we can calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM), the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines and the respective absorbed or emitted energy. We are able to explain the observed peculiar profiles of the BALs using the DACs/SACs theory, i.e. the complex profiles of the BALs are composed by a number of DACs or SACs which are created in different regions [2, 3].

In this paper we apply the GR model on the spectrum of the BALQSO PG 1254+047

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(Z=1.024), taken with HST (FOS/G160L,G270H), on February 17, 1993. We study the C IV λλ 1548.187, 1550.772 Å, Si IV λλ 1393.755, 1402.77 Å, N V λλ 1238.821, 1242.804 Å and Lyα λ 1215.68 Å lines.

RESULTS AND DISCUSSION

The best fit of the UV spectra with the model is shown in Figure 1. As one can see from Figure 1 there are several absorption components. In Table 1 we presented only the kinematical parameters of the absorption components, i.e. the random velocities of the studied ions as well as the rotational and radial velocities of the BALRs.

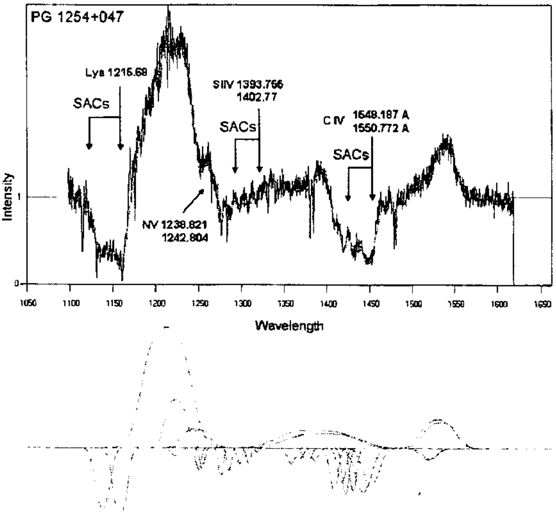

FIGURE 1. Best fit of the Lyα, N V, Si IV and C IV spectral lines. The components obtained from fit are given bottom.

As one can see in table 1, the values of the rotational velocities are too large (from 800 km/s to 1500 km/s) indicating that the region of origin of the components is close to the massive black hole. Such large rotational and random velocities are expected near the massive black hole, in difference the large widths observed in stellar spectra (see [4, 5]).

ACKNOWLEDGMENTS

This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by Ministry of Science of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

TABLE 1. Random (V_{rand}), Rotational (V_{rot}) and Radial (V_{rad}) velocities (in km/s) of the studied absorption regions.

Ion	Random Velocity	Rotational Velocity	Radial Velocity
Lyα	1162	1500	1973
	1598	1500	-14303
	1598	1500	-19235
	291	800	14895
	291	800	1726
	291	800	20098
	291	800	22688
	291	800	25154
N V	484	800	2658
Si IV	1768	1200	10442
	707	1000	5960
	581	1200	3002
	505	1000	-3645
	505	1000	-7719
C IV	1596	1000	-5804

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DACs and SACs in the UV Spectrum of the Quasar PG 0946+301

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Abstract. In this paper we study the C IV and Si IV resonance lines in the UV spectrum of the Broad Absorption Line Quasar (BAL QSO) PG 0946+301. The studied Broad Absorption Lines (BALs) are mainly created by a number of Satellite Absorption Components (SACs). However, the C IV doublet of PG 0946+301 is one of the very few lines that present clearly the DACs phenomenon, in the case of quasars. We applied the GR model and we calculated the apparent rotational (Vrot) and radial (Vrad) velocities of the regions where the studied lines are created and the random velocities (Vrand) of the C IV and Si IV ions.

Keywords: Quasars: BALQSOs, PG 0946+301, DACs, SACs
PACS: 98.54.Aj

INTRODUCTION

In the spectra of many quasars we observe complex profiles of broad absorption lines, mainly in the case of high ionization ions (e.g. C IV, Si IV, N V). These complex profiles are composed of a number of DACs or SACs which are created in the Broad Absorption Line Regions (BALR) that result from dynamical processes such as accretion, jets, ejection of matter etc.

By applying the model proposed by Danezis et al. [1] (GR model) we can accurately fit the observed complex profiles of both emission and absorption spectral lines. With this model we can calculate the apparent rotational and radial velocities, the random velocities of the ions, as well as the Full Width at Half Maximum (FWHM), the column density of the independent density regions of matter which produce the main and the satellite components of the studied spectral lines and the respective absorbed or emitted energy. We are able to explain the observed peculiar profiles using the DACs/SACs theory, i.e. the complex profiles are composed by a number of DACs or SACs which are created in different regions [2, 3].

In this paper we apply the GR model on the spectrum of the BALQSO PG 0946+301 (Z=1.216), taken with HST (FOS/G400,G570), on February 16, 1992. We study the C IV $\lambda\lambda$ 1548.187, 1550.772 Å, and Si IV $\lambda\lambda$ 1393.755, 1402.77 Å lines. We point out that the C IV doublet of this BALQSO is one of the very few lines that present clearly the DACs phenomenon.

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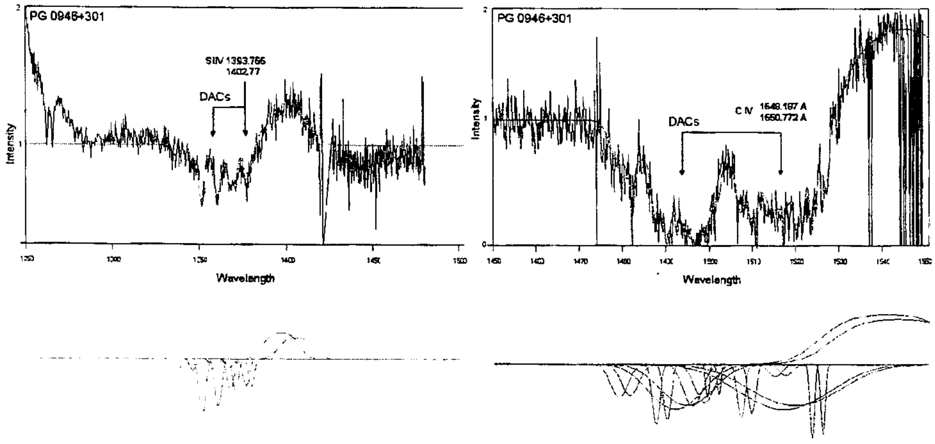

FIGURE 1. Best fit of the Si IV and C IV, resonance lines. We can explain the complex structure of these lines as a DACs or SACs phenomenon. Below the fit one can see the analysis of the observed profile to its DACs/SACs.

RESULTS

With GR model we were able to fit accurately the studied spectral lines (see Figure 1). Here we present only the kinematical parameters of the absorption components, i.e. the random velocities of the studied ions as well as the rotational and radial velocities of the BALRs that create the DACs or SACs of the studied lines. The calculated values are given in table 1. As one can see in table 1, some components of the C IV and Si IV resonance lines, present much larger radial velocities (large shifts). These absorption components are discrete (DACs) and appear on the left side of the main absorption features. On the other hand, the main absorption features are composed by a number of SACs (Figure 1).

TABLE 1. Random (V_{rand}), Rotational (V_{rot}) and Radial (V_{rad}) velocities (in km/s) of the studied regions

Ion	Random Velocity	Rotational Velocity	Radial Velocity
Si IV	505	400	-7611
	204	400	-9005
	204	400	-5617
	204	400	-12071
C IV	615	3000	-5998
	615	1800	-10835
	228	600	-10061

As one can see in table 1, the values of the rotational velocities of the first two C IV components are too large. In order to explain this large broadening, we propose a new idea, based on the theory of SACs phenomenon [4, 5]. The observed very large width is due to the existence of many narrow absorption lines which are created due to micro-turbulence effects. This means that around the main density region where the main spectral line is created, there may exist some micro-turbulent movements that give rise to some narrow absorption components with different shifts, around the main spectral line. If these lines are many and have small differences in their radial velocities, they blend among themselves (SACs phenomenon) and the result may be a very broad absorption line. Thus, the very broad absorption line might result from the composition of many narrow absorption lines that are created by micro-turbulent effects.

ACKNOWLEDGMENTS

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Calculation of the shifts of argon spectral lines

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Abstract. Shifts due to collisions with charged particles (Stark broadening) and neutral atoms, were determined for nine argon spectral lines corresponding to the transitions $3p^5nd$ - $3p^54p$ for n = 4 - 7, $3p^56s$ - $3p^54d$ and $3p^54p'$ - $3p^54s$ in order to estimate their usability for the research and diagnostics of a plasma in a surface-wave discharge at atmospheric pressure.

Keywords: Line broadening, collisional broadening, plasma diagnostics, electron density
PACS: 32.60.+i; 32.70.Jz; 52.20.Fs; 52.20.Hv

INTRODUCTION

In the previous works [1, 2, 3] the broadening of argon spectral lines emitted from surface wave plasma at atmospheric pressure have been studied. The purpose was to obtain the electron density in this type of discharge using the widths of spectral lines of the working gas, without any impurities and contaminations of the plasma.

In this work we look for the shift values of the same argon spectral lines. If their values are significant enough to be measured, it is possible to use them for plasma diagnostic too.

THEORETICAL CALCULATIONS

The theoretical calculations of the shifts of argon spectral lines have been made using semi-classical impact theory. Under atmospheric pressure the shifts of the spectral lines are due to: (i) the interactions between the emitters and the charged particles (Stark shift) and (ii) the interactions emitters - neutral atoms in a ground state.

Stark shifts

In this work, the Stark shifts have been calculated using Sahal-Bréchot theory [4, 5]. Within the semi-classical perturbation formalism, the Stark shift (d) of an isolated line originating from the transition between the initial level i and the final level f is expressed as:

$$d_{St} = n_e \int_0^\infty v f(v) dv \int_{\rho_3}^{\rho_d} 2\pi\rho d\rho \sin 2\phi_p \tag{1}$$

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where n_e and v are the electron density and the velocity of perturbers respectively, $f(v)$ is the Maxwellian distribution of electron velocities, and ρ is the impact parameter. The phase shift ϕ_p is due to the polarization potential The cut-off parameter ρ_3, the Debye cut-off ρ_d and the symmetrization procedure are described in [4, 5].

Shift due to collisions with neutral atoms

The shift by the neutral atoms has been treated using semi-classical theory in impact approximation where the shift value d_K is given by:

$$d_K = N < \sigma'' v > = N\delta \qquad (2)$$

where N is the perturber density, σ'' is the effective cross section for the impact line shift, δ is the shift coefficient, v is the relative velocity between the radiator and the perturber. Here the symbols <...> denote the thermal average over a Maxwellian distribution of the relative velocities of the interacting atoms. The interactions between the emitter and the rare-gas atoms are described using Kaulakys potential [6]. It is approximated by a superposition of polarization potentials and the Fermi pseudopotential. The polarization potentials describe the long range interactions: (i) excited electron - perturber interaction; (ii) three body interaction between the excited electron and perturber in the presence of emitter core and (iii) emitter core - perturber interaction.

RESULTS

Results for the Stark shifts of nine argon spectral lines corresponding to the transitions $3p^5nd$ - $3p^54p$ for n = 4 - 7, $3p^56s$ - $3p^54d$ and $3p^54p'$ - $3p^54s$ have been obtained. The Stark shift calculations have been performed [2] for particular lines within multiplets (spin-orbital interaction has been included, the most appropriate for argon atom j-L coupling has been used) for temperature 10^4 K at a perturber density of 10^{14} cm^{-3}. Since 85% of the shift of the studied lines is due to the interactions between the emitters and electrons, the above temperature is ascribed to the electrons.

The atomic data needed for the calculations have been obtained as follows: the values of the energy levels have been taken from NIST catalogue: http://physics.nist.gov/, and the oscillator strengths have been calculated within the Bates and Damgaard approximation.

The positive (red) shifts have been deduced for all examined argon lines. The calculation of the shift values due to collisions with neutral atoms has been made for atmospheric pressure at gas temperature 1600 K, which is experimentally obtained in [1]. Opposite to the Stark shift, the shift values by neutrals are negative for all spectral lines. Comparison of the Stark shift [2] and the shift caused by the neutral atoms, both theoretically determined, and the dependence of the shift versus effective quantum number are presented in Figure 1. In fact, the argon spectral lines emitted by lower energy levels with effective quantum number $n^* < 5$ are not shifted by collisions with the surrounding

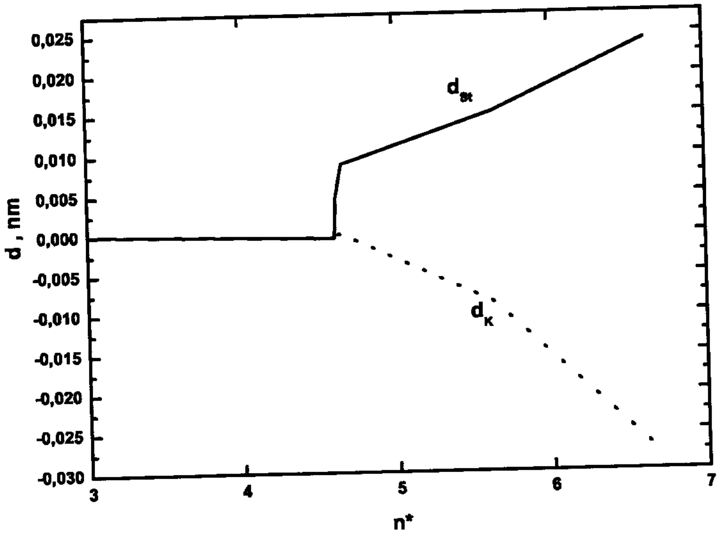

FIGURE 1. Stark shift (d_{St}: $ne = 10^{14}$ cm^{-3}, electron temperature 10^4 K) and shift due to collisions with neutral atoms (d_K: $p = 1$ atm, gas temperature 1600 K) of the argon spectral lines versus effective quantum number (n^*).

particles, in the plasma at the examined conditions. The absolute values of the both shifts increase with effective quantum number, for shift by neutrals it is more rapidly.

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SPECTRAL LINE SHAPES

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AUSTIN, TX 1990

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AN EXAMINATION OF REGULARITIES IN NEUTRAL ATOM BROADENING

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Regularities and similarities in the widths of spectral lines perturbed by neutral atoms have been studied in order to find out if they are apparent to such a degree that they can be used to obtain data by interpolation and hence provide a tool for the critical evaluation of new experimental results. The principal results on the clearly identified regularities will be published soon[1].

The Van der Waals result for the theoretical half-half width, w(theory), has been used in conjunction with the critically selected data of Allard and Kielkopf[2], w(experiment), to search for regularities in transitions along a spectral series and for corresponding transitions in homologous emitters. The dependence of line widths on the perturber properties has also been examined.

We define the quantity

$$f(C_6,\mu,T) = C_6^{2/5}(T/\mu)^{3/10},$$

where C_6 is the Van der Waals coefficient, μ is the reduced mass of the emitter-perturber system, T is the temperature and all quantities are in atomic units. Results for the resonance transitions of the alkalis perturbed by rare gases are shown in figure 1. The scatter of the data about the average value of w(experiment)/w(theory) is less for larger values of $f(C_6,u,T)$, which corresponds to larger values of C_6 and hence to where the longer-range part of the interatomic potential becomes dominant in determining the width. Our results also show that better agreement between theory and experiment is obtained if the Van der Waals formula is multiplied by a factor of about 1.25-1.5. This can be explained by studying figure 2 where accurate potentials, V(R), for Na-Ne are plotted as a ratio to their asymptotic value, $-C_6/R^6$. It is seen that true convergence to the Van der Waals limit only occurs for R > 50 a.u., a much larger value of R than is often assumed, but that the curves have a maximum at much lower values of R. This behaviour is typical of all alkali-rare gas interactions.

Work is in progress on the development of a new simple formula for the line width that is an improvement on the pure Van der Waals formula. All the long-range polarisation terms in the emitter-perturber interaction are included with the Van der Waals potential being regained in the limit of large R. Preliminary results are shown in figure 3 for the data of figure 1 but with w(theory) being the new simple formula. The results are very encouraging, since the average value of the ratio is much closer to unity and the spread in the data is also reduced.

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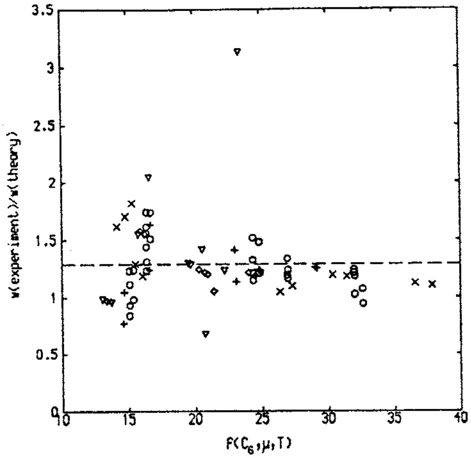

Figure 1

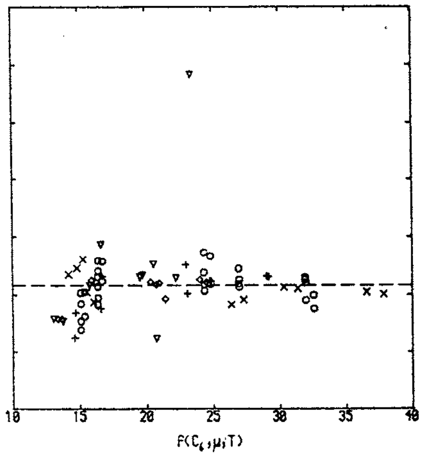

Figure 3

In figure 1, w(theory) is given by the Van der Waals formula and in figure 3, w(theory) is given by the new simple formula. The average values of w(experiment)/w(theory) are 1.285 and 1.082, and the resonance lines of Li, Na, K, Rb and Cs are denoted by ×, o, +, ◇ and ▽ respectively.

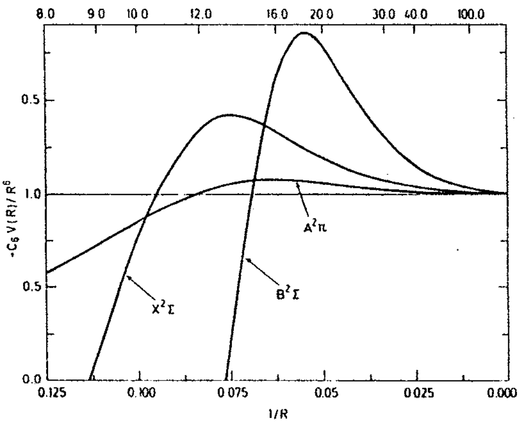

Fig. 2. The adiabatic potentials for the $X^2\Sigma$, $B^2\Sigma$ and $A^2\Pi$ states for the system Na-Ne.

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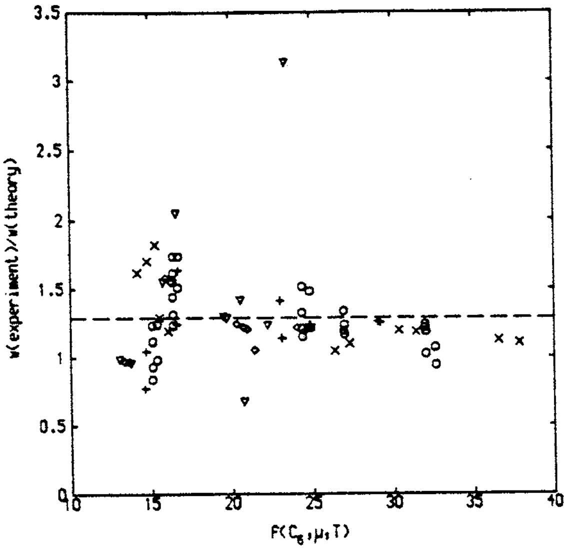

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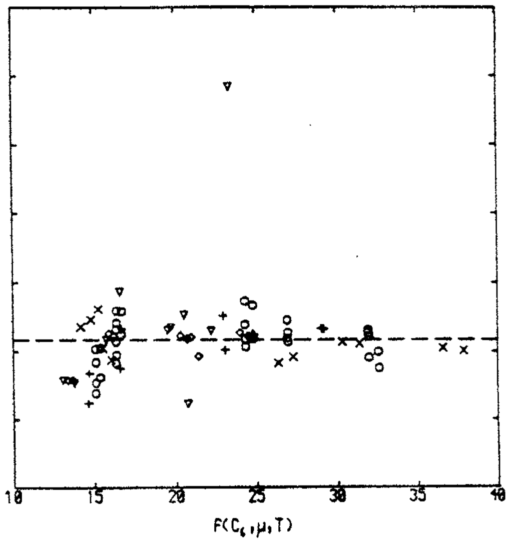

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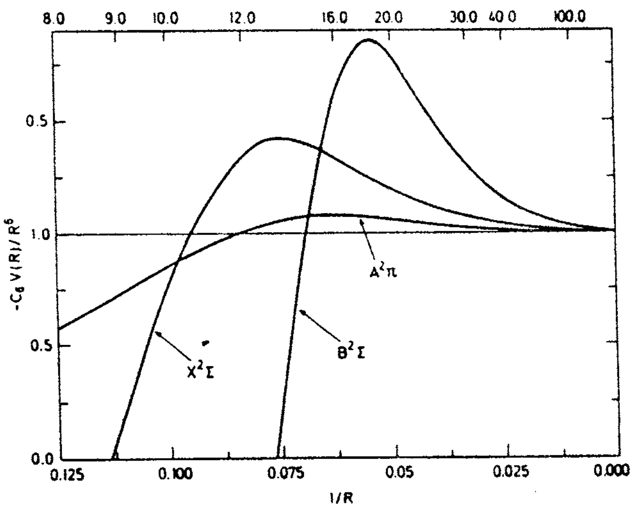

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PLASMA BROADENING OF BrI AND II LINES FROM $(^1D_2)$np LEVELS

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ABSTRACT

Systematic experimental and theoretical study of Stark broadening of BrI and II lines from $(^1D_2)$np levels has been performed.

INTRODUCTION

Recently, results of a study of the Stark broadening and shift of halogen atom lines in a plasma of a wall stabilized arc have been reported[1,2,3]. Comparison between experimental results and simple theoretical calculations has shown large discrepancy for BrI lines from $(^1D_2)5p\,^2P^0$ not detected for the lines of other transitions of halogen atoms[1,2,3]. In order to trace the causes of this puzzling discrepancy we performed systematic experimental and theoretical study of plasma broadening of spectral lines from $(^1D_2)$np levels of BrI and II.

EXPERIMENTAL RESULTS AND COMPARISONS

As a plasma source we used wall stabilized arc[1,2,3]. Experimental procedure and plasma diagnostics techniques were described elsewhere[1,2,3]. Details of theoretical calculations are given in refs. 4,5 and 6. Comparison of experimental results for BrI and II lines given in Table I together with theoretical data [4,5,6] shows better agreement with calculations from a simple theoretical approach (see ratios w_m/w_{SSC} in Table I). However, both sets of theoretical calculations show large discrepancy with the experiment for the lines of BrI originating from $(^1D_2)5p\,^2P^0$ level. None of the results for other transitions (see Table I) including line from BrI ($^1D_2$)5p$^2D^0$ bear any resemblance to the transitions from ($^1D_2$)5p$^2P^0$ levels. Since in our theorteical calculations only dipole allowed transitions were taken into account an attempt is made to explain this large discrepancy by the influence of forbidden transition.

Table I Experimental data for full-halfwidths w_m in Å units. Experimental results are compared with theoretical ones calculated using semiclassical method[4,5] w_{SC} and simplified semiclassical approach[6] w_{SSC}.

TRANSITION	T (K)	N (10^{16}cm^{-3})	w_m (Å)	w_m/w_{SC}	w_m/w_{SSC}
BrI					
$(^3P_2)5s\,^4P_{3/2} - (^1D_2)5p\,^2P^0_{3/2}$	9800	3.25	1.06	7.16	2.92
$(^3P_1)5s\,^2P_{3/2} - (^1D_2)5p\,^2P^0_{3/2}$	9800	3.15	1.09	5.83	2.44
$(^3P_0)5s\,^2P_{1/2} - (^1D_2)5p\,^2P^0_{1/2}$	9800	3.15	0.85	4.08	1.62
$(^1D_2)5s\,^2D_{5/2} - (^1D_2)5p\,^2D^0_{5/2}$	9600	2.80	0.98	2.59	1.02
II					
$(^3P_2)5d\,[1]_{3/2} - (^1D_2)6p\,[2]^0_{3/2}$	9300	2.00	1.43	2.40	1.52
$(^3P_2)5d\,[3]_{5/2} - (^1D_2)6p\,[2]^0_{5/2}$	9400	2.20	1.69	2.57	1.68
$(^3P_2)6s\,[2]_{5/2} - (^1D_2)6p\,[3]^0_{7/2}$	9400	2.30	0.29	3.42	1.71
$(^3P_2)5d\,[3]_{5/2} - (^1D_2)6p\,[3]^0_{7/2}$	9300	2.00	1.47	2.50	1.62

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TEMPERATURE DEPENDENCE OF THE TRIPLY IONIZED OXYGEN STARK WIDTHS

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INTRODUCTION

Broadening and shift of spectral lines in plasmas are subject of numerous experimental studies. Unfortunately, most of the reported data are from the measurements at a single electron temperature or in the best case the results are taken in a small temperature range. Tne lack of the experimental data in a wider temperature range makes a detailed test of the Stark broadening theoretical calculations unreliable. Furthermore, without the knowledge of the line width and shift dependence upon electron temperature comparison of the experimental results obtained at different plasma conditions becomes very difficult.

The aim of this paper is to supply the experimental and theoretical data for the widths of the prominent triply ionized oxygen lines in a large electron temperature range. The reported experimental results together with other experimental data will be used for the testing of various theoretical calculations.

THEORY

By using the semiclassical-perturbation formalism[1] we have calculated electron-, proton-, and ionized helium-impact line widths for O IV $3s^2S-3p^2P^o$ and $3p^2P^o-3d^2D$ multiplets and the results are given in Table 1.

TABLE 1.

		PERTURBER		
Transition	T [K]	Electrons Width [A]	Protons Width [A]	Ionized He Width [A]
3s-3p	40000	1.100e-01	2.380e-02	3.250e-03
3066.4 [A]	70000	8.560e-02	3.660e-03	4.420e-03
c=0.28e21	100000	7.410e-02	4.440e-03	5.200e-03
	170000	6.100e-02	5.630e-03	5.880e-03
3p-3d	40000	1.170e-01	2.230e-03	3.080e-03
3410.9 [A]	70000	9.100e-02	3.620e-03	4.310e-03
c=0.34e21	100000	7.840e-02	4.410e-03	5.200e-03
	170000	6.420e-02	5.850e-03	6.050e-03

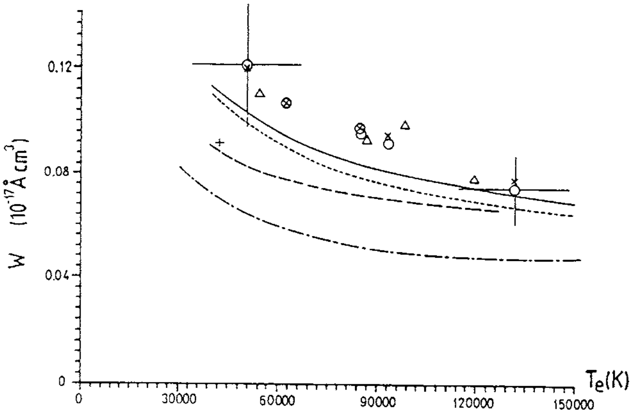

Fig 1. Full Stark widths (refered to an density of $10^{17}cm^{-3}$) for the O IV 3s-3p multiplet vs electron temperature. Theory: ___, semiclassical, electrons + He^+ impact widths, ..., semiclasical, electrons only (see Table 1.), _ _, semiclassical aproximation[5,4], _._, modified semiempirical formula[5].

EXPERIMENT AND COMPARISONS

The Stark widths of the O IV lines belonging to the multiplets form Table 1 are measured in the plasma (initial gas mixture $He:O_2$=98.6:1.4) of a low preasure pulsed arc. Electron densities in the range $(2.1\text{-}6.4)\times10^{17}cm^{-3}$ were determined from the width of the He II P_α line while electron temperatures between 50800 and 131800 K are measured from the Boltzman plot of O IV line intensities. Our experimental results for $3s^2S\text{-}3p^2P^o$ multiplet are compared in Fig.1 with other experiments[2,3] and our semiclassical results from Table 1. For comparison other simplified theoretical approaches[4,5] are taken as well.

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INFLUENCE OF THE OSCILLATOR STRENGTHS ON THE STARK BROADENING OF Rb I LINES

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INTRODUCTION

Neutral Rubidium Stark-broadening parameters are of significance for laboratory plasma research [1] as well as for Solar and stellar spectroscopy, since Rb I lines have been observed in solar and stellar spectra[2]. By using the semiclassical-perturbation formalism[3,4], we have calculated electron-, proton-, and ionized argon-impact line widths and shifts for 24 Rb I multiplets. The obtained results for Stark broadening parameters will be published elsewhere[5]. Here, we will discuss the results for Rb I, along with a comparison with experimental data and other theoretical results. We will discuss moreover, the influence of the oscillator strength (**f**) values on the obtained results.

RESULTS AND DISCUSSION

In Table I, the present results with Ar II -impact contribution included, are compared with experimental data[1]. In all cases we added to Stark broadening parameters due to electron-impacts, our results for Ar II - impact broadening. We see that the agreement between experimental and theoretical values is particularly good for shifts.

In order to see the influence of oscillator strength values on the results, calculations have been repeated with oscillator strengths calculated by using relativistic single- configuration Hartree-Fock method with allowance for core polarization, which have been taken from Table IV (values denoted as RHF+CP) in Ref. 6, and with oscillator strengths from Ref. 7, where allowance for configuration mixing and for spin-orbit interaction has been made. Different availlable results for the needed oscillator strengths are compared in Table IV of Ref. 5. One can see that the most important difference is for 5p-5d transition where with the Bates and Damgaard method the value of 0.731 have been obtained while in Refs. 6 (Table IV, values under RHF+CP) and 7 we have 0.0396 and 0.0265 respectively. In Ref. 8, several effective single-, and multiple-parameter model potentials have been compared, and for the critical 5p-5d transition the corresponding **f**-value varies between 0.0396 and 0.360. In Ref. 8

authors concluded that there is no significant improvement in computed oscillator strengths and sometimes even deterioration of accuracy is observed for more sophysticated calculations. We can see in Table I that the best agreement with experimental data is for oscillator strengths obtained within the Coulomb approximation, while in the case of more sophysticated **f**-values even the sign of shift is different from the experimental one. This is maybe a consequence of the fact that within the Coulomb approximation we have a summation over the complete and consistent set of atomic data. If we use better oscillator strength values for particular transition, the final result is not always better since this consistency might be disturbed if we use a mix of values from different sources.

Table I Comparison between the experimental Stark full half-widths (W) and shifts (d) of Rb I lines within the 5s^{2}S - 5p^{2}P^o multiplet with different calculations. The meaning of indexes is : m experimental values of Purić et al (1977)/1/; DSB-present results; fMB-present results with the oscillator strengths taken from table IV (values denoted as RHF+CP) in Ref.6; fW-present results with oscillator strengths taken from Ref.7. The electron density N is equal to 10^{17} cm^{-3}.

λ (Å)	T (K)	Wm (Å)	WDSB (Å)	WfMB (Å)	WfW (Å)	dm (Å)	dDSB (Å)	dfMB (Å)	dfW (Å)
7800.2	15000	1.66	1.31	1.09	1.08	0.52	0.59	-0.31	-0.23
	17500	1.70	1.35	1.13	1.13	0.50	0.57	-0.32	-0.25
	20800	1.76	1.42	1.18	1.18	0.47	0.54	-0.34	-0.26
	26000	1.92	1.51	1.25	1.26	0.51	0.50	-0.35	-0.28
7947.6	15000	1.82	1.31	1.09	1.08	0.55	0.59	-0.31	-0.23
	17500	1.92	1.35	1.13	1.13	0.53	0.57	-0.32	-0.25
	20800	2.00	1.42	1.18	1.18	0.50	0.54	-0.34	-0.26
	26000	2.20	1.51	1.25	1.26	0.45	0.50	-0.35	-0.28

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INFLUENCE OF THE OSCILLATOR STRENGTHS ON THE STARK BROADENING OF Rb I LINES

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Plasma Broadening and Shifting of Analogous Spectral Lines Along Isoelectronic Sequences

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Abstract. The Stark widths and shifts of the $3s^2S$-$3p^2P^0$ transitions along the isoelectronic sequences of lithium and boron, the $3s^3S$-$3p^3P^0$ transitions of beryllium sequence and the $3p^2P^0$-$3d^2D$ transitions of boron sequence have been studied theoretically using impact semiclassical method and experimentally observed in the plasma of a low pressure pulsed arc. The plasma electron densities were determined from the width of the HeII P_α line while the electron temperatures were measured from relative line intensities. To estimate the influence of different ions to the Stark width of lines, evaluation of the plasma composition data is performed and in conjunction with our theoretical results contribution of ion broadening estimated. Furthermore in our theoretical calculations for the first time we included the influence of perturbing levels with different parent therms to width and shift of the investigated OIV spectral lines.

THEORY

By using the semiclassical-perturbation formalism [1] we have calculated electron and all relevant perturbing ions impact broadening parameters for the $3s^2S$-$3p^2P^0$ transitions along the isoelectronic sequences of lithium and boron, the $3s^3S$-$3p^3P^0$ transitions of beryllium sequence and the $3p^2P^0$-$3d^2D$ transitions of boron sequence. Energy levels needed for these calculations have been taken from [2]. Oscillator strengths were calculated by using the method described in [3], see also [4]. The contribution of higher energy levels is estimated as in [5].

EXPERIMENT

The light source was a low pressure pulsed arc with a quartz discharge tube 10 mm internal diameter. The distance between aluminum electrodes was 161 mm, and 3 mm diameter holes were located at the center of both electrodes to allow end-on plasma observations. A 30 mm diaphragm placed in front of the focusing mirror ensures that light comes from the narrow cone about the arc axis. All plasma observations are performed with 1-m monochromator with inverse linear dispersion 0.833 nm/mm in the first order of the diffraction grating, equipped with the photomultiplier tube and stepping motor. The discharge was driven by: 15.2 μF low inductance capacitor charged to 3.0; 3.8 and 6.0 kV, critically damped current pulse duration τ = 7.7 μs, pressure of the gas mixtures p = 3 torr, The spectral line profiles were recorded with instrumental half widths of 0.0168 nm. The experimental apparatus and procedure are briefly described in [6].

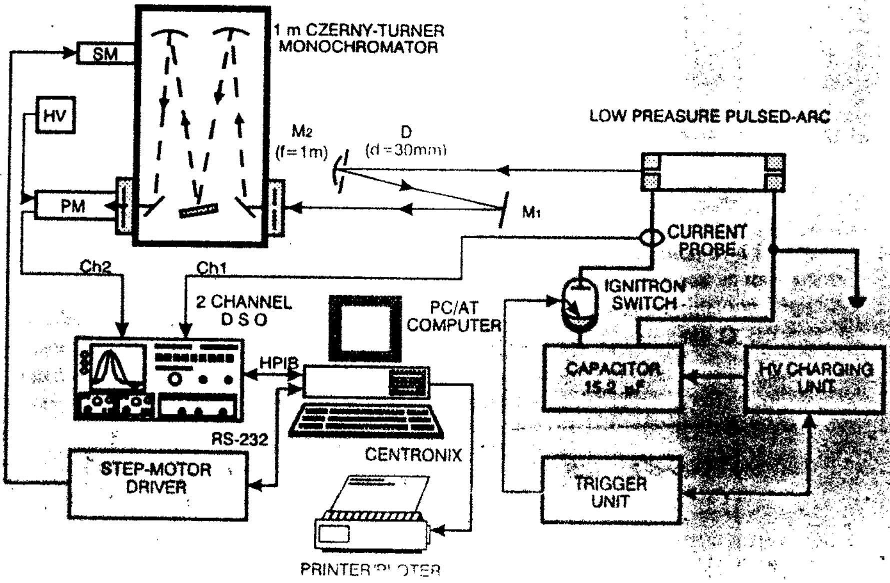

Figure 1. The experimental setup.

EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results for Stark widths and comparisons with theoretical results for $3s^2S-3p^2P^0$ transitions along the isoelectronic sequences of lithium and the $3s^3S-3p^3P^0$ transitions of beryllium sequence are given in Figs.2-3 while the experimental results for the $3s^2S-3p^2P^0$ and the $3p^2P^0-3d^2D$ transitions of boron sequence are given in Fig.4. In order to evaluate contribution of ion impact widths it was necessary to compute plasma composition data for the conditions of width measurements. In the studied electron temperature range and within the estimated uncertainties the experimental Stark widths agree well with the results of our semiclassical electron impact widths. The only exception are BII lines which agree better with modified semiempirical formula [7] see Fig.2. For the conditions of the present experiment, estimated contribution of the ion broadening has never exceeded seven percents of the total line width. So within the precision of this experiment it was not possible to detect its contribution with certainty.

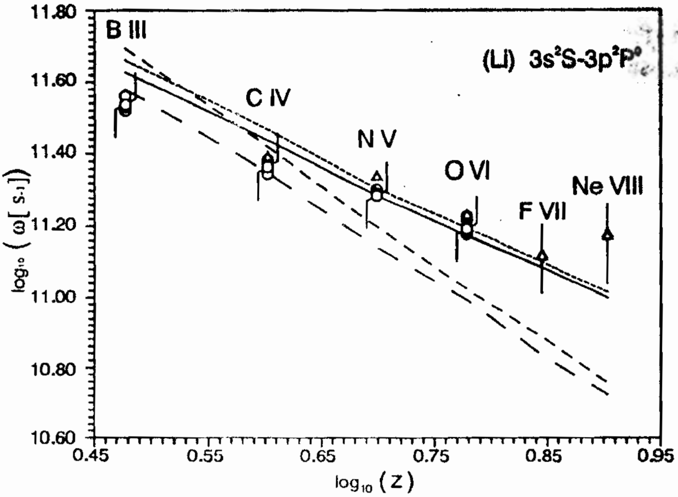

Figure 2. Stark widths Li-like spectral lines (in angular frequency units) as a function of $\log_{10}Z$ for $3s^2S-3p^2P^0$ multiplets. Theory: ········ , semiclassical electrons + ions impact widths, ——, semiclassical electrons only; - - -, semiclassical approximation (Eq.(526) taken from [8]); — — —, modified semiempirical formula [7]. Experiment: O, our data; Δ, Glenzer et al [9,10].

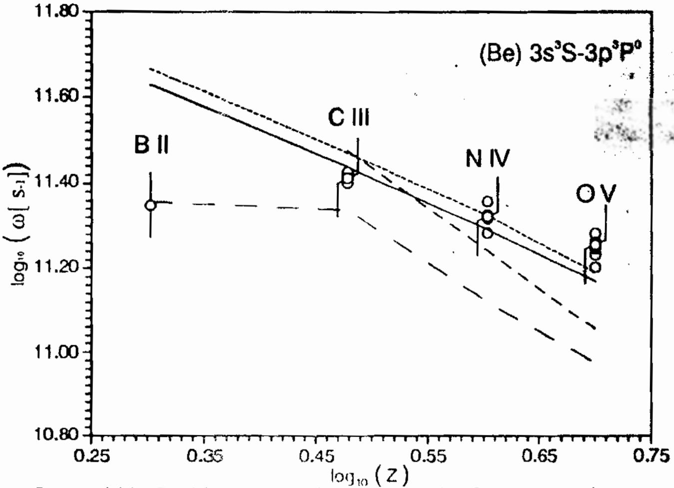

Figure 3. Stark widths Be-like spectral lines (in angular frequency units) as a function of $\log_{10}Z$ for $3s^3S-3p^3P^0$ multiplets. Theory: ········ , semiclassical electrons + ions impact widths, ——, semiclassical electrons only; - - -, semiclassical approximation (Eq.(526) taken from [8]); — — —, modified semiempirical formula [7]. Experiment: O, our data.

The first calculation of our semiclassical electron impact shifts of the investigated spectral lines shows an agreement within estimated uncertainties with the experimental Stark shifts, except for the 3s-3p and the 3p-3d transitions of OIV and the 3s-3p transitions of NIV, NV and CIV which had the opposite sign in relation to the experimentally measured ones. For OIV, we included several transitions with different parent terms which change the sign of the shift [12]. The improved calculations for OIV shifts are in an good agreement with the experiment. Further calculations are in progress.

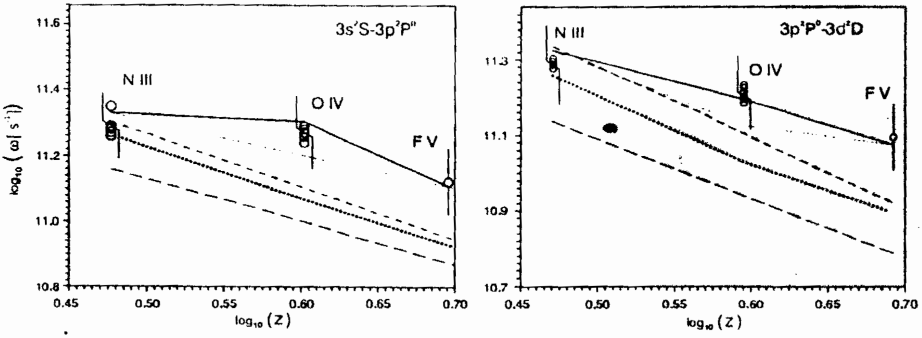

Figure 4. Stark widths B-like spectral lines (in angular frequency units) as a function of $\log_{10}Z$ for $3s^2S$-$3p^2P^0$ and $3p^2P^0$-$3d^2D$ multiplets. Theory: ········, semiclassical electrons + ions impact widths, ——, semiclassical electrons only; - - -, semiclassical approximation (Eq.(526) taken from [8]); — — —, modified semiempirical formula [7]. Experiment: O, our data; Δ, Glenzer et al [11].

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On the Stark Broadening of B III Spectral Lines

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 12 Be III and 27 B III multiplets. The obtained results have been compared with available experimental and theoretical data. The complete results will be published elsewhere. Here, we discuss the comparison of results for B III, with experimental and other theoretical data.

For studies as e.g. numerical modelling of stellar plasma or abundance determinations, data on B III lines may be of interest. Moreover, Stark broadening of B III lines is of interest for the investigation and diagnostic of laboratory and laser-produced plasma, as well as for the research of regularities and systematic trends. In (1)-(3) Stark widths of B III lines have been calculated within the semiempirical method (4), the modified semiempirical method (5), the simplified semiclassical method ((6), Eq. 526) and its modification (5). Moreover, Stark widths and shifts for B III 2s - 2p, 2s - 3p, 2p - 3s, 2p - 3d, 3s - 3p and 3p - 3d have been calculated by Seaton (7) within the quantum mechanical strong coupling method. Stark broadening parameters of B III have been also investigated experimentaly in two contributions. In Djeniže *et al.* (8), the results concerning the B III 4f $^2F^\circ$ - 5g^2G 4497.6 Å line, measured in a pulsed linear arc plasma, have been reported. Srećković *et al.* (9) measured in a linear, low-pressure pulsed arc operating in O_2, the Stark widths of two lines within the B III *2s* ^2S - *2p* $^2P^\circ$ multiplet.

The B III Stark broadening data are of interest and for studies of regularities and systematic trends within isoelectronic sequences. In our previous articles, Stark broadening data for Be II, C IV, N V, O VI, F VII, Ne VIII, Na IX, Al XI, Si XII all belonging to the lithium isoelectronic sequence have been calculated. Consequently, the results for B III will complete this set of data.

By using the semiclassical-perturbation formalism (10, 11), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 27 B III

By using the semiclassical-perturbation formalism (10, 11), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 27 B III multiplets, for perturber densities 10^{17} - 10^{21} cm^{-3} and temperatures T = 10,000 - 300,000K, in order to continue our research of multiply charged ion line Stark broadening parameters.

The unique experimental result convenient for comparison, is the Stark widths of the two lines within the B III $2s\ ^2S$ - $2p\ ^2P^\circ$ multiplet, measured by Srećković *et al.* (9) in a linear, low-pressure pulsed arc operating in O_2. They found a large disagreement between their Stark widths and the results of (1), obtained within the modified semiempirical approach (5). For the B III 2065.77 Å line, they found that the ratio of measured to theoretical Stark width is 7.8 and for 2067.23 Å line 6.7 for the temperature of 48000 K at an electron density of 2.55 x 10^{17} cm^{-3}. Corresponding ratios with our results with ionized oxygen-impact broadening included, are 3.9 and 3.5 respectively, which is better but not satisfying.

We may compare available theoretical results for B III $2s\ ^2S$ - $2p\ ^2P^\circ$ multiplet for the temperature of 160000 K at an electron density of 1 x 10^{17} cm^{-3}. Our full width at half maximum is W = 0.0103 Å, and the agreement is closest with calculations of Dimitrijević and Konjević (1) who used the simplified semiclassical approach of Griem ((6), Eq. 526), since they obtained W = 0.00892 Å. Within the modified semiempirical approach (5), same authors obtained W = 0.00449 Å, which is two times smaller. Within the close coupling quantum mechanical approach Seaton (7) obtained W = 0.00602 Å, which is also in disagreement with experiment and with our calculations. In order to clarify the situation, particularly since B III $2s\ ^2S$ - $2p\ ^2P^\circ$ multiplet is important for the consideration of Stark broadening parameters within the lithium isoelectronic sequence, we recommend a new experimental determination of Stark broadening parameters particularly for this multiplet.

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On the Stark Broadening of B III Spectral Lines

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 12 Be III and 27 B III multiplets. The obtained results have been compared with available experimental and theoretical data. The complete results will be published elsewhere. Here, we discuss the comparison of results for B III, with experimental and other theoretical data.

For studies as e.g. numerical modelling of stellar plasma or abundance determinations, data on B III lines may be of interest. Moreover, Stark broadening of B III lines is of interest for the investigation and diagnostic of laboratory and laser-produced plasma, as well as for the research of regularities and systematic trends. In (1)-(3) Stark widths of B III lines have been calculated within the semiempirical method (4), the modified semiempirical method (5), the simplified semiclassical method ((6), Eq. 526) and its modification (5). Moreover, Stark widths and shifts for B III 2s - 2p, 2s - 3p, 2p - 3s, 2p - 3d, 3s - 3p and 3p - 3d have been calculated by Seaton (7) within the quantum mechanical strong coupling method. Stark broadening parameters of B III have been also investigated experimentaly in two contributions. In Djeniže *et al.* (8), the results concerning the B III 4f $^2F^\circ$ - 5g^{2}G 4497.6 Å line, measured in a pulsed linear arc plasma, have been reported. Srećković *et al.* (9) measured in a linear, low-pressure pulsed arc operating in O_2, the Stark widths of two lines within the B III $2s\ ^2S$ - $2p\ ^2P^\circ$ multiplet.

The B III Stark broadening data are of interest and for studies of regularities and systematic trends within isoelectronic sequences. In our previous articles, Stark broadening data for Be II, C IV, N V, O VI, F VII, Ne VIII, Na IX, Al XI, Si XII all belonging to the lithium isoelectronic sequence have been calculated. Consequently, the results for B III will complete this set of data.

By using the semiclassical-perturbation formalism (10, 11), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 27 B III

By using the semiclassical-perturbation formalism (10, 11), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 27 B III multiplets, for perturber densities 10^{17} - 10^{21} cm^{-3} and temperatures T = 10,000 - 300,000K, in order to continue our research of multiply charged ion line Stark broadening parameters.

The unique experimental result convenient for comparison, is the Stark widths of the two lines within the B III $2s\ ^2S$ - $2p\ ^2P^o$ multiplet, measured by Srećković *et al.* (9) in a linear, low-pressure pulsed arc operating in O_2. They found a large disagreement between their Stark widths and the results of (1), obtained within the modified semiempirical approach (5). For the B III 2065.77 Å line, they found that the ratio of measured to theoretical Stark width is 7.8 and for 2067.23 Å line 6.7 for the temperature of 48000 K at an electron density of 2.55 x 10^{17} cm^{-3}. Corresponding ratios with our results with ionized oxygen-impact broadening included, are 3.9 and 3.5 respectively, which is better but not satisfying.

We may compare available theoretical results for B III $2s\ ^2S$ - $2p\ ^2P^o$ multiplet for the temperature of 160000 K at an electron density of 1 x 10^{17} cm^{-3}. Our full width at half maximum is W = 0.0103 Å, and the agreement is closest with calculations of Dimitrijević and Konjević (1) who used the simplified semiclassical approach of Griem ((6), Eq. 526), since they obtained W = 0.00892 Å. Within the modified semiempirical approach (5), same authors obtained W = 0.00449 Å, which is two times smaller. Within the close coupling quantum mechanical approach Seaton (7) obtained W = 0.00602 Å, which is also in disagreement with experiment and with our calculations. In order to clarify the situation, particularly since B III $2s\ ^2S$ - $2p\ ^2P^o$ multiplet is important for the consideration of Stark broadening parameters within the lithium isoelectronic sequence, we recommend a new experimental determination of Stark broadening parameters particularly for this multiplet.

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On the Stark Broadening of Mg II Spectral Lines

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 67 Mg II multiplets. The obtained results have been compared with available experimental and theoretical data. The complete results will be published elsewhere. Here, we discuss the comparison of our results with experimental and other theoretical data.

The study Mg II lines does not only interest laboratory plasma research and plasma devices development. Due to the cosmical abundance of magnesium and its ionization potential value, Mg II lines are present in solar and stellar spectra and the corresponding Stark broadening data are important for stellar spectra analysis and synthesis, as well as for abundance determinations and stellar plasma modelling and research.

In order to provide the needed Stark broadening data, we have calculated within the semiclassical - perturbation formalism (1, 2) electron-, proton-, and ionized helium-impact line widths and shifts for 67 Mg II multiplets, for a perturber range of densities 10^{16} - 10^{19} cm^{-3} and temperatures T = 5,000 - 150,000 K. We discuss here the obtained results, together with a comparison with experimental and other theoretical data.

A detailed critical analysis of Mg II experimental data with the special emphasis on Mg II 3s - 3p resonance line has been performed in (3), and it was concluded that the results of Goldbach et al. (4) and Roberts and Barnard (5), which adequately account for the critical factors, provide the most reliable data for the Mg II resonance lines. These results are in accordance with the strong coupling quantum mechanical calculations (6,7) and about two times smaller than results of full semiclassical calculations (present results and results from (8, 9). One should be noted that the semi - classical method gives often results of lower accuracy for ionic resonance lines, especially at lower temperatures, since the full quantum mechanical approach is needed for appropriately including the various short range effects. We notice a good agreement between semiempirical calculations performed in (10) with the Griem's semiempirical (11) and the modified semiempirical approach (12), with the most reliable experimental results (Roberts and Barnard (5), Goldbach *et al.* (4) and with the quantum mechanical calculations (Bely and Griem (7) ; Barnes (6)). This is promising for the use of the much simpler modified semiempirical method (12) when there are no sophisticated results available, or when the use of the quantum close-coupling sophisticated method needs a considerably higher effort and does not promise a higher accuracy (e.g. lack of reliable atomic data or very high levels involved). For non - resonant lines there are much less data, which are additionaly of lower accuracy. Our results are in excellent agreement with the experimental result of Chapelle and Sahal - Bréchot (13) for the Mg II 3d - 4f transition, which has the best experiment accuracy for non-resonant lines according to critical reviews of experimental data (3, 14, 15).

One can see that there are less experimental data for the shift and that they are of lower accuracy. It is difficult to make a final conclusion since even the sign of experimental shifts are different. New and high precision measurements would be very useful.

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On the Stark Broadening of Mg II Spectral Lines

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A detailed critical analysis of Mg II experimental data with the special emphasis on Mg II 3s - 3p resonance line has been performed in (3), and it was concluded that the results of Goldbach et al. (4) and Roberts and Barnard (5), which adequately account for the critical factors, provide the most reliable data for the Mg II resonance lines. These results are in accordance with the strong coupling quantum mechanical calculations (6,7) and about two times smaller than results of full semiclassical calculations (present results and results from (8, 9). One should be noted that the semi - classical method gives often results of lower accuracy for ionic resonance lines, especially at lower temperatures, since the full quantum mechanical approach is needed for appropriately including the various short range effects. We notice a good agreement between semiempirical calculations performed in (10) with the Griem's semiempirical (11) and the modified semiempirical approach (12), with the most reliable experimental results (Roberts and Barnard (5), Goldbach *et al.* (4) and with the quantum mechanical calculations (Bely and Griem (7) ; Barnes (6)). This is promising for the use of the much simpler modified semiempirical method (12) when there are no sophisticated results available, or when the use of the quantum close-coupling sophisticated method needs a considerably higher effort and does not promise a higher accuracy (e.g. lack of reliable atomic data or very high levels involved). For non - resonant lines there are much less data, which are additionaly of lower accuracy. Our results are in excellent agreement with the experimental result of Chapelle and Sahal - Bréchot (13) for the Mg II 3d - 4f transition, which has the best experiment accuracy for non-resonant lines according to critical reviews of experimental data (3, 14, 15).

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The Project for the Determination of Stark Broadening Parameters within the Modified Semiempirical Approach: Ag II

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Abstract. Investigations of the Stark line broadening parameters are important for a number of problems in laboratory and astrophysical plasma research. We use a modified semiempirical approach in order to complete a set of the Stark broadening data. Here we present the Stark broadening data for 6 Ag II spectral lines calculated within the modified semiempirical approach.

INTRODUCTION

Investigations of the Stark line broadening parameters are important for a number of problems in laboratory and astrophysical plasma research as e.g. analysis and synthesis of stellar spectra and modeling of stellar atmospheres and spectra. The Belgrade group (M. S. Dimitrijević, L. Č. Popović, V. Kršljanin, D. Tankosić and N. Milovanović) uses the modified semiempirical approach [1] in order to complete as much as possible the existing set of the Stark broadening data available to users in physics and astrophysics. The modified semiempirical approach is used in the case when the energy level data, needed for the reliable full semiclassical calculation, are not completed sufficiently. Up to now, this group has performed Stark broadening parameter calculations for Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, La II, Au II ,Eu II,Ti II, Kr II, Na II ,Y II, Zr II, Sc II, Ra II, Be III, B III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III, La III, V III, Ti III, Bi III, Sr III, Cu III, Co III, Zr III, B IV, Cu IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, NeV, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI and Cl VI spectral lines [see e.g. Ref. 2 and references therein], using the modified semiempirical approach.

Also, considering that Au II λ=174.048nm, Co II λ=230.785nm and Ti II λ=376.132nm lines have been used for gold, cobalt and titanium abundance determination (see e.g. Refs. 3, 4 for gold, Ref. 5 for cobalt and Ref. 6 for titanium) in HgMn stars, this group has tested the influence of Stark broadening mechanism on equivalent widths of these lines for an A type star atmosphere, as well as for DA and DB white dwarfs [7]. This has been done with the help of Kurucz's model atmospheres

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[8] of an A type star (T_{eff}=10000K, log g=4), and with Wickramasinghe's models of DA (T_{eff}=10000K, log g=6) and DB (T_{eff}=15000K, log g=7) white dwarf atmospheres [9].

RESULTS AND DISCUSSION

There is not neither experimental nor theoretical Stark broadening data for singly charged Ag in lines except for the $4d^{10}\ ^1S$-$5p^1P^o$ resonant Ag II spectral line where Stark-broadening data have been estimated, based on regularities and systematic trends [10]. Here we present the Stark broadening data for 6 Ag II spectral lines calculated within the modified semiempirical approach. Calculations were performed for an electron density of 10^{23} m^{-3}, within the temperature range 5000-50000 K. Energy level data were taken from [11]. Oscillator strengths have been calculated by using the method of Bates and Damgaard [12]. In Table 1 the Stark broadening parameters for the 6 Ag II spectral lines, as a function of temperature, are shown.

TABLE 1. The Stark broadening parameters for 6 Ag II spectral lines, as a function of temperature, at an electron density of 10^{23} m^{-3}.

Transition	T(K)	W(nm)	d (nm)
$5s\,^1D_2 - 5p\,^2P_1^0$ λ=228.07 nm	5000	0.659E-02	-0.127E-03
	10000	0.459E-02	-0.812E-04
	20000	0.318E-02	-0.440E-04
	30000	0.256E-02	-0.237E-04
	40000	0.221E-02	-0.926E-05
	50000	0.199E-02	0.399E-05
$5s^1D_2 - 5p^2D_2^0$ λ=223.03 nm	5000	0.657E-02	-0.134E-03
	10000	0.458E-02	-0.871E-04
	20000	0.317E-02	-0.500E-04
	30000	0.256E-02	-0.304E-04
	40000	0.221E-02	-0.158E-04
	50000	0.200E-02	-0.441E-05
$5s^1D_2 - 5p^2F_2^0$ λ= 232.10 nm	5000	0.694E-02	-0.308E-03
	10000	0.483E-02	-0.214E-03
	20000	0.335E-02	-0.144E-03
	30000	0.270E-02	-0.112E-03
	40000	0.234E-02	-0.894E-04
	50000	0.211E-02	-0.747E-04
$5p^1P_1^0 - 6s^1D_2$ λ= 281.61nm	5000	0.154E-01	-0.435E-02
	10000	0.108E-01	-0.315E-02
	20000	0.745E-02	-0.234E-02
	30000	0.601E-02	-0.201E-02
	40000	0.518E-02	-0.183E-02
	50000	0.466E-02	-0.172E-02

TABLE 1 - continued.

Transition	T(K)	W(nm)	d (nm)
$5p\ ^3D_2^0 - 6s\ ^1D_2$ λ= 289.71 nm	5000	0.168E-01	-0.459E-02
	10000	0.117E-01	-0.333E-02
	20000	0.809E-02	-0.247E-02
	30000	0.653E-02	-0.212E-02
	40000	0.564E-02	-0.193E-02
	50000	0.508E-02	-0.181E-02
$5p\ ^1F_3^0 - 6s\ ^1D_2$ λ=275.71 nm	5000	0.149E-01	-0.391E-02
	10000	0.104E-01	-0.283E-02
	20000	0.722E-02	-0.210E-02
	30000	0.583E-02	-0.180E-02
	40000	0.503E-02	-0.164E-02
	50000	0.453E-02	-0.153E-02

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Long Term Variability of the Radial Velocities in the Coronal and Post-coronal Regions of the Oe Star HD 93521

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Abstract. We examine the timescale changes of C IV, N IV and N V spectral lines of the Oe star HD 93521, during a period of 16 years, applying the model proposed by Danezis et al. (2005). We found that the spectral lines consist of one or more Satellite Absorption Components (SACs or DACs) which construct the whole spectral profile. In this paper we present the time scale variation of the radial velocities.

Keywords: Oe stars, SACs, radial velocity.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh

INTRODUCTION

HD 93521 is a relatively bright, very rapidly rotating O9.5V star (Hobbs et al. 1982). These characteristics, together with its exceptionally high Galactic latitude (b=+63.130, Galactic length l=183.30, Costero & Stalio 1984) have made it a favorite target for studies regarding stars out of the Galactic plane (e.g. Pettini & West 1982).

Since its adoption as a spectrophotometric standard for IUE (Bohlin et al. 1980), it has acquired an increasingly well – documented record of spectroscopic variability (Garmany et al. 1980). The ultraviolet spectrum shows wind signatures at C IV, N V, and Si IV. The presence of a strong Si IV wind line is exceptional for a luminosity class V star; indeed, all the wind profiles have unusual morphologies (Prinja & Howarth 1986), which have been interpreted as evidence for a cylindrically (as opposed to spherically) symmetric wind (Massa 1992). According to C IV resonance line profile of HD 93521, Massa (1992) and Howarth & Reid (1993) also suggested, that there is a high – speed component in the polar outflow from the star as well as a low – speed component in the equatorial regions. Howarth & Reid (1993) supported that the mean profiles of the resonance lines of C IV, NV and SiIV show that the morphology of the lines is very unusual, and it is possible to identify three separate components: very strong, low - velocity absorption in Si IV and C IV, which is saturated out about -500 km/s; weaker absorption which extends to about -1200 km/s in C IV and N V and emission in C IV and N V which is unusually strong for a late O main sequence star.

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THE GAUSSIAN - ROTATIONAL MODEL (GR-MODEL)

With the following model we can calculate the apparent rotational and radial velocities, the Gaussian deviation of the random motions of the ions, the random velocities of these motions, as well as the optical depth, the Full Width at Half Maximum (FWHM), the absorbed and the emitted energy and the product of the Source function S and the optical depth ξ of the independent regions of matter which produce the main and the satellites components (SACs) of the studied spectral lines.

For our study the line broadening is caused by two reasons: The first one is the rotational velocity of the spherical region that produce the spectral line and the second one the random velocities of the ions, which make thermal random motions. In this model we present a new approach, which describes both of these factors.

We consider that the area of gas, which creates a specific spectral line consists of i independent absorbing shells followed by j independent shells that both absorbs and emits and an outer absorbing shell. Such a structure produces DACs or SACs (Danezis et al. 2003) and the final line function is:

$$I_\lambda = \left[I_{\lambda 0} \prod_i \exp\{-L_i \xi_i\} + \sum_j S_{\lambda ej} \left(1 - \exp\{-L_{ej} \xi_{ej}\}\right) \right] \exp\{-L_g \xi_g\} \qquad (1)$$

where: $I_{\lambda 0}$**:** the initial radiation intensity,

L_i, L_{ej}, L_g: are the distribution functions of the absorption coefficients $k_{\lambda i}$, $k_{\lambda ej}$, $k_{\lambda g}$ respectively. Each L depends on the values of the apparent rotational velocity as well as of the radial expansion/contraction velocity of the density shell, which forms the spectral line *(V_{rot}, V_{exp})*,

$\xi = \int_0^s \Omega \rho \, ds$ is an expression of the optical depth τ, where Ω is an expression of k_λ, $S_{\lambda ej}$: the source function, which, at the moment when the spectrum is taken, is constant.

The function (1) does not depend on the geometry of the regions which create the observed feature. This means that L may represent any distribution which considers certain geometry, without changing anything in I_λ.

One of the hypotheses when we constructed the rotational model was that the line's width $\Delta\lambda$ is only a rotational effect. This means that the random velocities were very low and they did not contribute to the line broadening. In a new approach of the problem we also consider the parameter of random velocities in the calculation of the distribution function *L* and we have:

$$L\,(\lambda) = \frac{\sqrt{\pi}}{2\lambda_0 z} \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left[erf\left(\frac{\lambda - \lambda_0}{\sigma\sqrt{2}} + \frac{\lambda_0 z}{\sigma\sqrt{2}} \cos\theta \right) - erf\left(\frac{\lambda - \lambda_0}{\sigma\sqrt{2}} - \frac{\lambda_0 z}{\sigma\sqrt{2}} \cos\theta \right) \right] \cos\theta \, d\theta \qquad (2)$$

where λ_0 is the laboratory wavelength of a spectral line that arises from a specific point A_i of the equator of a spherical shell, $z = \frac{V_{rot}}{c}$ (V_{rot} is the rotational velocity of the point A_i). This *L(λ)* of the equation (2) is the distribution that replaces the rotational distribution *L* that Danezis et al (2003) proposed (see Danezis et al. 2003 and Danezis et al. 2005a,b).

LONG TERM VARIABILITY OF THE RADIAL VELOCITIES

The Analysis Of The Shapes

This study is based on eleven different spectra of HD 93521 taken with the IUE – Data satellite. We study the structure of the spectral lines C IV λλ 1548.155 Ǻ, 1550.774 Ǻ, N IV λ 1718.80 Ǻ and N V λλ 1238.821, 1242.804 Ǻ.

We present some spectral lines and their best fits of the C IV, N IV and N V regions of three different dates. These are the IUE - data SWP04472 (4.3.79), SWP44900 (9.6.72) and SWP30086 (12.1.87) respectively.

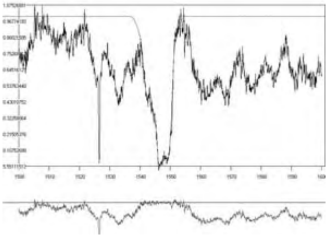

FIGURE 1. The C IV λλ 1548.155, 1550.774 Ǻ resonance lines in the spectrum of HD 93521. Each of C IV spectral lines consists of five SACs. The graph bellow the fit indicates the difference between the observed spectrum and the fit.

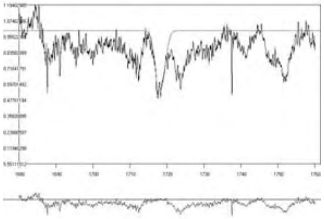

FIGURE 2. The N IV λ 1718.80 Ǻ absorption line in the spectrum of HD 93521. The N IV spectral line consists of one SAC. The graph bellow the fit indicates the difference between the observed spectrum and the fit.

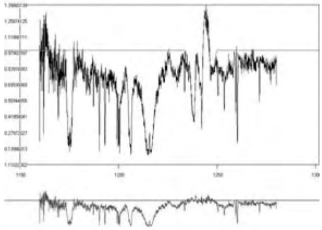

FIGURE 3. Each of N V λλ 1238.821, 1242.804 Ǻ resonance lines in the spectrum of HD 93521 shows a characteristic P Cygni profile. Each of these spectral lines consists of one SAC. The graph bellow the fit indicates the difference between the observed spectrum and the fit.

Results

The following diagrams describe the time scale changes of the radial velocities of the coronal regions where are created the C IV, the N IV and the N V ions. We took into account that the shift of the interstellar lines corresponds to a mean value of the radial velocity about -387 km/s. We took also into account that the radial velocity of the star is about -11 km/s (Garmany et al. 1980).

The C IV Region

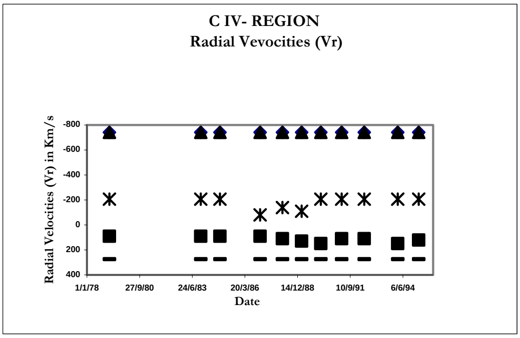

FIGURE 4. Timescale variations of the apparent radial velocities V_{rad} (km/s) of the λλ 1548.155, 1550.774 Å C IV resonance lines for the independent density regions of matter which create the 5 satellite components. We see that the radial velocity in each component remains constant.

The N IV Region

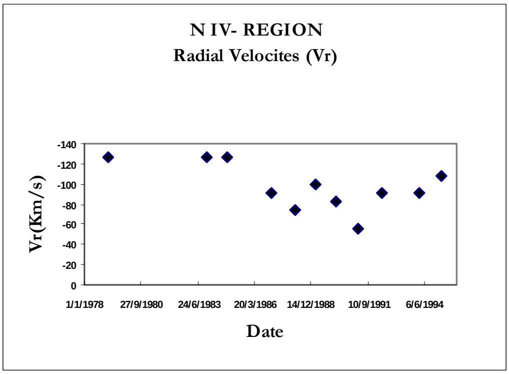

FIGURE 5. Time scale changes of the apparent radial velocities V_{rad} (km/s) of the density region which creates the N IV spectral line λ 1718.8 Å. The time scale variability is remarkable.

The N V Region

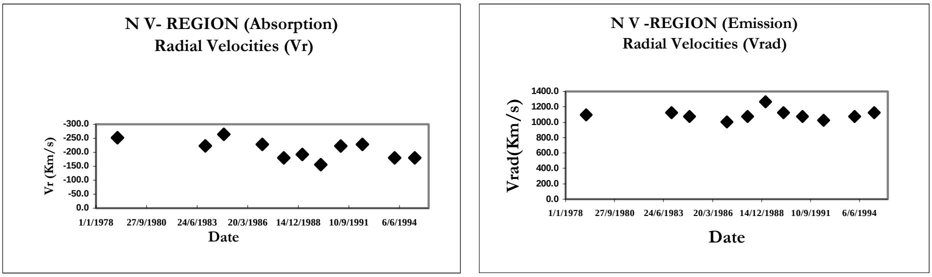

FIGURE 6. Timescale variations of the mean values of the apparent radial velocity V_{rad} (km/s) of the absorption and emission component of the N V resonance lines λλ 1238.821, 1242.804 Å. In each case we note also remarkable time scale variability.

ACKNOWLEDGMENTS

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A New Modeling Approach For DACs And SACs Regions In The Atmospheres Of Hot Emissions Stars

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Abstract. The presence of Discrete Absorption Components (DACs) or Satellite Absorption Components (SACs) is a very common phenomenon in the atmospheres of hot emission stars (Danezis et al. 2003, Lyratzi & Danezis 2004) and result to the complex line profiles of these stars. The shapes of these lines are interpreted by the existence of two or more independent layers of matter nearby a star. These structures are responsible for the formation of a series of satellite components for each spectral line. Here we will present a model reproducing the complex profile of the spectral lines of Oe and Be stars with DACs and SACs (Danezis et al. 2003, Lyratzi & Danezis 2004). In general, this model has a line function for the complex structure of the spectral lines with DACs or SACs and include a function L that considers the kinematic (geometry) of an independent region. In the calculation of the function L we have considered the rotational velocities of the independent regions, as well as the random velocities within them. This means that the new function of L is a synthesis of the rotational distribution and a physical Gaussian. Finally, we calculate the optical depth (ξ) and the column density (d) of each independent density region.

Keywords: Hot emission stars, models, DACs.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh

INTRODUCTION

One of the most important phenomena in the spectra of hot emission stars is the DACs (Discrete Absorption Components) phenomenon (Peton 1974, Underhill 1975, Lamers et al. 1982, Sahade et al. 1984, Sahade & Brandi 1985, Hutsemékers 1985, Danezis 1984, 1987, Danezis et al. 1991, 2003).

DACs are discrete but not unknown absorption spectral lines. They are spectral lines of the same ion and the same wavelength as a main spectral line, shifted at different Δλ, as they are created in different density regions which rotate and move radially with different velocities (Danezis et al. 2003, Lyratzi & Danezis 2004). DACs are lines, easily observed, when the regions that give rise to such lines, rotate with low velocities and move radially with high velocities. However, if the regions, that give rise to such lines, rotate with large velocities and move radially with small velocities,

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the produced lines are very broadened but have small shifts. As a result they are blended among themselves as well as with the main spectral line and thus they are not discrete. In such a case the name Discrete Absorption Component is inappropriate and we use only the name SACs (Satellite Absorption Components).

DESCRIPTION OF THE MODEL

The Line Profile Function

Some years ago our group proposed a new model to explain the complex structure of the density regions of hot stars, where the spectral lines that present SACs or DACs are created (Danezis et al. 1991, 1998, 2000a,b,c, 2002a,b,c, 2003), Laskarides et al. 1992a,b).

The main hypothesis of this model is that the atmospherical region where a specific line is created is not continuous, but it is composed of a number of successive independent absorbing density regions, a number of emission regions and an external general absorption region.

By solving the equations of radiation transfer through a complex structure, as the one described, we conclude to a function for the line’s profile, able to give the best fit for the main spectral line and its Satellite Components in the same time (Equation 1).

$$I_\lambda = \left[I_{\lambda 0} \prod_i e^{-x_{ai}} + \sum_j S_{\lambda ej} \left(1 - e^{-x_{ej}}\right) \right] e^{-x_g} \tag{1}$$

where: $I_{\lambda 0}$: is the initial radiation intensity, $S_{\lambda ej}$ is the source function, which, at the moment when the spectrum is taken, is constant and $e^{-x_{ai}}$, $e^{-x_{ej}}$, e^{-x_g} are the distribution functions of the absorption, emission and general absorption lines respectively. This function I_λ does not depend on the geometry of the regions which create the observed feature.

The Rotation Distribution Function

One of the main hypotheses when we constructed the old version of the model (rotation model) was that the line's width Δλ is only a rotational effect and we consider spherical symmetry for the independent density regions, which create the satellite components. This means that the random velocities were very low and they did not contribute to the line broadening. In such a case Eq. (1) becomes:

$$I_\lambda = \left[I_{\lambda 0} \prod_i e^{-L_{ai}\xi_{ai}} + \sum_j S_{\lambda ej} \left(1 - e^{-L_{ej}\xi_{ej}}\right) \right] e^{-L_g \xi_g} \tag{2}$$

where: $I_{\lambda 0}$: is the initial radiation intensity, L_{ai}, L_{ej}, L_g: are the distribution functions (Rotation distribution) of the absorption coefficients $k_{\lambda ai}$, $k_{\lambda ej}$, $k_{\lambda g}$, respectively and ξ is the optical depth.

In the present work we propose a new approach of the problem, as we also consider the parameter of random velocities in the calculation of the distribution function L (See Danezis et al. 2005). This new L is a synthesis of the rotation distribution that we had presented in the old rotational model and a Gaussian. This means that the new *L* has two limits, the first one gives us a Gaussian and the other the old rotation distribution.

Calculation Of The New Distribution Function (Gauss-Rotation)

Let us consider a spherical shell and a point A_i in its equator (See Fig. 1a). If the laboratory wavelength of a spectral line that arises from A_i is λ_{lab}, the observed wavelength will be $\lambda_0=\lambda_{lab}+\Delta\lambda_{rad}$.

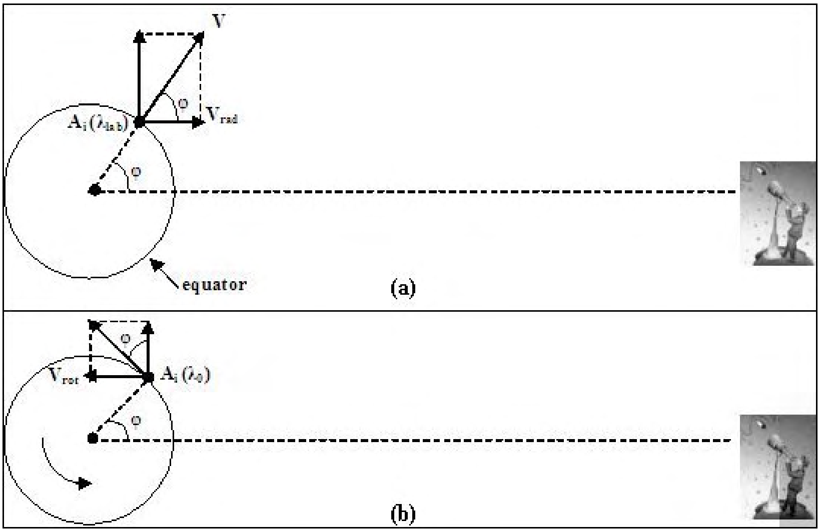

FIGURE 1. View of the equator of a blob. We can see the V_{rad} of the point A_i, from which arise the $\Delta\lambda_{rad}$ (a) and the V_{rot} from which arise the $\Delta\lambda_{rot}$ (b).

If the spherical density region rotates (See Fig. 1b), we will observe a displacement $\Delta\lambda_{rot}$ and the new wavelength of the center of the line λ_i is $\lambda_i=\lambda_0\pm\Delta\lambda_{rot}$, where $\Delta\lambda_{rot}=\lambda_0 z\sin\varphi$ and $z=\frac{V_{rot}}{c}=\frac{\Delta\lambda_{rot}}{\lambda_0\sin\varphi}$, where V_{rot} is the observed rotational velocity of the point A_i.

This means that $\lambda_i=\lambda_0\pm\lambda_0 z\sin\varphi=\lambda_0(1\pm z\sin\varphi)$ and if $-\frac{\pi}{2}<\varphi<\frac{\pi}{2}$ then $\lambda_i=\lambda_0(1-z\sin\varphi)$.

If we consider that the spectral line profile is a Gaussian distribution we have: $P(\lambda)=\frac{1}{\sqrt{2\pi}\sigma}e^{-\left[\frac{\lambda-\kappa}{\sigma\sqrt{2}}\right]^2}$ where κ is the mean value of the distribution and in the case of the line profile it indicates the center of the spectral line that arises from A_i. This means that $P(\lambda)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\left[\frac{\lambda-\lambda_0(1-z\sin\varphi)}{\sigma\sqrt{2}}\right]^2}=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{[\lambda-\lambda_0(1-z\sin\varphi)]^2}{2\sigma^2}}$. For all the semi-equator we have $L(\lambda)=\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{[\lambda-\lambda_0(1-z\sin\varphi)]^2}{2\sigma^2}} \cos\varphi d\varphi$. If we make the transformation $\sin\varphi = x$ and $u=\frac{\lambda-\lambda_0(1-zx)}{\sqrt{2}\sigma}$ then $L(\lambda)=\frac{1}{\lambda_0 z\sqrt{\pi}}\int_{\frac{\lambda-\lambda_0(1+z)}{\sigma\sqrt{2}}}^{\frac{\lambda-\lambda_0(1-z)}{\sigma\sqrt{2}}} e^{-u^2}du$ or

$$L(\lambda)=\frac{1}{\lambda_0 z\sqrt{\pi}}\left[\int_0^{\frac{\lambda-\lambda_0(1-z)}{\sigma\sqrt{2}}} e^{-u^2}du-\int_0^{\frac{\lambda-\lambda_0(1+z)}{\sigma\sqrt{2}}} e^{-u^2}du\right]$$

and $L(\lambda)=\frac{\sqrt{\pi}}{2\lambda_0 z}\left[erf\left(\frac{\lambda-\lambda_0(1-z)}{\sqrt{2}\sigma}\right)-erf\left(\frac{\lambda-\lambda_0(1+z)}{\sqrt{2}\sigma}\right)\right]$.

The distribution function from the semi-spherical region is

$$L_{final}(\lambda)=\frac{\sqrt{\pi}}{2\lambda_0 z}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\left[erf\left(\frac{\lambda-\lambda_0}{\sqrt{2}\sigma}+\frac{\lambda_0 z}{\sqrt{2}\sigma}\cos\theta\right)-erf\left(\frac{\lambda-\lambda_0}{\sqrt{2}\sigma}-\frac{\lambda_0 z}{\sqrt{2}\sigma}\cos\theta\right)\right]\cos\theta d\theta \quad (3)$$

(Method Simpson).

This $L_{final}(\lambda)$ is the distribution that replaces the old rotational distribution L in equation (2) that our group proposed some years ago (Danezis et al 2003).

ACKNOWLEDGMENTS

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A New Approach For The Structure Of Ha Regions In 120 Be-type Stars

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Abstract. In this paper we present a statistical study of the Hα line profiles of 120 Be-type stars using the model proposed by Danezis et al. (2003) and Lyratzi & Danezis (2004). This model proposes that the density layers which produce the Hα line lie in different regions in the stellar atmosphere. In the Be-type stellar atmospheres, there are two regions that can produce the Hα satellite components. The first one lies in the chromosphere and the second one in the cool extended envelope. By fitting the Hα line profiles with the line function of the proposed model we are able to calculate: a) For the chromospheric absorption components we calculated the rotational and radial velocities as well as the optical depth. b) For the emission and absorption components which are created in the cool extended envelope we calculated the radial velocities, the FWHM and the optical depth. Finally, we present the relation between these parameters with the spectral subtype and the luminosity class.

Keywords: Hot emission stars, models, DACs.
PACS: 97.10.Ex, 97.10.Fy, 97.20.Ec, 97.30.Eh

INTRODUCTION

In the spectra of many Oe and Be stars some spectral lines are accompanied by Discrete Absorption Components (DACs) (Bates & Halliwell 1986, Prinja 1988, Willis et al. 1989, Bates & Gilheany 1990, Gilheany et al. 1990, Waldron et al. 1994, Henrichs et al. 1994, Telting et al. 1993, Telting & Kaper 1994, Cranmer & Owocki 1996, Prinja et al. 1997, Fullerton et al. 1997, Kaper et al. 1996, 1997, 1999, Cranmer et al. 2000) or Satellite Absorption Components (SACs) (Peton 1974, Lamers et al. 1982, Sahade et al. 1984, Sahade & Brandi 1985, Hutsemékers 1985, Danezis 1987, Danezis et al. 1991, 2003, Laskarides et al. 1992a,b, Lyratzi and Danezis 2004).

The DACs were considered to be unknown spectral lines, which accompanied some spectral lines (Si IV, C IV, N IV, N V, Mg II) in the spectra of Oe and Be stars (Bates & Halliwell 1986, Prinja 1988, Willis et al. 1989, Bates & Gilheany 1990, Gilheany 1990, Kaper et al. 1990, Waldron et al. 1994, Henrichs et al. 1994, Telting et al. 1993, Telting & Kaper 1994, Cranmer & Owocki 1996, Prinja et al. 1997, Fullerton et al. 1997, Kaper et al. 1996, 1997, 1999, Cranmer et al. 2000).

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DACs, now, are not unknown absorption spectral lines, but spectral lines of the same ion and the same wavelength as the main spectral line, shifted at different Δλ, as they are created in different density regions which rotate and move radially with different velocities.

If the regions, where such lines are created, rotate quickly and move radially slowly, the produced lines are quite broadened and with small shifts. So, they may not be discrete absorption spectral lines, but blended among themselves. In such a case, they are not observable, but we can detect them through the analysis of the profile. As Peton (1974) first pointed out, these components appear as "satellites" in the violet or in the red side of a main spectral line, as a function of the time or the phase, in the case of a binary system. For these two reasons and in order to include all these components, either they are discreet or not, to a unique name, we prefer to name them Satellite Absorption Components (SACs) and not Discrete Absorption Components (DACs).

MECHANISMS RESPONSIBLE FOR THE SACs' CREATION

The creation of SACs is due to mechanisms which allow the existence of structures which cover all or a significant part of the stellar disk, such as shells, blobs or puffs (Underhill 1975, Underhill & Fahey 1984, Bates & Halliwell 1986, Grady et al. 1987, Lamers et al. 1988, Cranmer & Owocki 1996, Kaper et al. 1996, 1997, 1999, Markova 2000) or interaction of fast and slow wind components, Corrotation Interaction Regions (CIRs), structures due to magnetic fields or spiral streams as a result of the star's rotation (Underhill & Fahey 1984, Mullan 1984a,b, 1986, Prinja & Howarth 1988, Cranmer & Owocki 1996, Fullerton et al. 1997, Kaper et al. 1996, 1997, 1999, Cranmer et al. 2000).

Though we do not know yet the mechanism responsible for the formation of such structures, it is positive that the SACs result from independent high density regions in the stars' environment (Fig. 1). These regions are formed by the specific ions which create a specific spectral line.

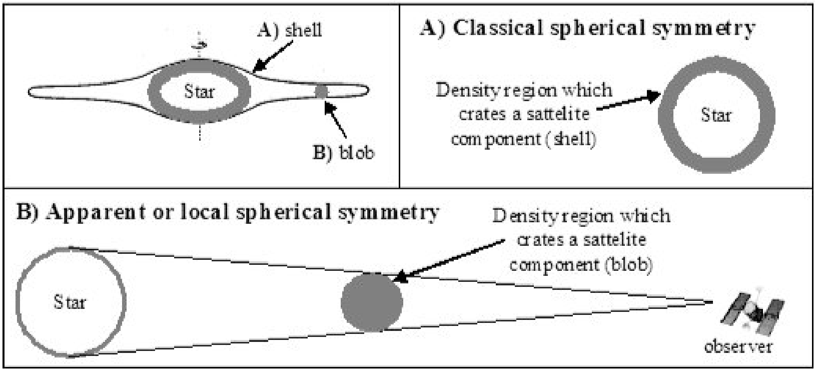

FIGURE 1. Density regions which create the Satellite Absorption Components.

THE USED MODEL

Danezis et al. (2003) constructed a mathematical model, in order to study the atmospheric regions that give rise to SACs.

By solving the equations of radiation transfer through a complex structure as the one described, we conclude to a function for the line's profile, able to give the best fit for the main spectral line and its Satellite Absorption Components in the same time. Such a best fit, through the function of the line's profile, enables us to calculate some parameters (rotational and radial velocities, FWHM, optical depth) of the independent layers of matter, which form the main spectral line and its satellite absorption components. (See Danezis et al. 2005a, b, Lyratzi et al. 2005).

$$I_{\lambda} = \left[I_{\lambda 0} \prod_i e^{-\tau_i} + \sum_j S_{\lambda ej} \left(1 - e^{-\tau_j}\right) \right] e^{-\tau_g} \qquad (1)$$

where: $I_{\lambda 0}$: is the initial radiation intensity, $S_{\lambda ej}$ is the source function, which, at the moment when the spectrum is taken, is constant and $e^{-\tau_i}$, $e^{-\tau_j}$, $e^{-\tau_g}$ are the appropriate distribution functions (Gauss, Lorentz, Voigt, Rotation) of the absorption, emission and general absorption lines respectively. This function I_{λ} does not depend on the geometry of the regions which create the observed feature.

APPLICATION TO THE Hα LINE OF 120 Be STARS

In our study we use the stellar spectrographs which were taken by Andrillat & Fehrenbach (1982) and Andrillat (1983) (resolution 5,5 and 27 Å). We applied the model on the Ha line 6562.817 Å in the spectra of 120 Be stars of all the spectral subtypes and luminosity classes. In most of the Be stellar spectra the Ha line presents peculiar and complex profiles. Usually the Ha line's profile consists of: a very broad absorption feature, an emission feature and a narrow absorption feature (Fig. 2).

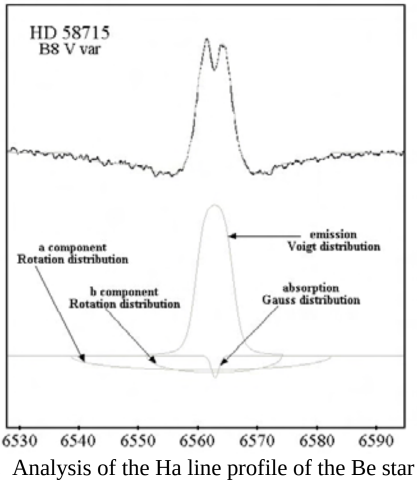

FIGURE 2. Analysis of the Ha line profile of the Be star HD 58715.

We applied the proposed model in order to reproduce these complex profiles. We tried to fit the observed profiles by applying all the classical distribution functions (Gauss, Lorentz, Voigt, Rotation). We concluded that the best fit is accomplished when we fit: a) the very broad absorption component with Rotation distribution, b) the emission component with Voigt distribution and c) the narrow absorption component with Gauss distribution.

CONCLUSIONS

The proposed line function $I_\lambda = \left[I_{\lambda 0} \prod_i e^{-\tau_i} + \sum_j S_{\lambda ej}\left(1 - e^{-\tau_j}\right)\right] e^{-\tau_g}$ is able to reproduce accurately the complex Hα profiles of all the 120 studied Be-type stars. This means that the regions where the Ha line is created are not continuous, but they consist of successive independent density regions. In the place of the exponential $e^{-\tau}$, which gives the profile of each component, we apply the appropriate distribution function. The choice of the appropriate distribution function depends on the physical conditions of the regions which create the SACs. The most important point is that, in any case, the proposed line function remains the same. The important advantage of this method is that we are able to accomplish the best fit of the observed spectral lines, by applying a line function, to which we conclude after the solution of the radiation transfer equations, through a complex atmospherical structure, and not by a graphical composition of mathematical distribution functions with no physical meaning.

The existence of SACs is a general phenomenon in the spectra of Be-type stars.

The absorption regions of the Hα line, lie in two different atmospherical regions: in the chromosphere and in the cool extended envelope. In the chromosphere we detected one to five successive, independent density regions, which rotate with 5200±1192 km/s, 990±170 km/s, 536±68 km/s, 352±37 km/s and 152±46 km/s and move radially with 15±121 km/s, 7±123 km/s, 19±62 km/s, 15±60 km/s and -2±42 km/s. Each region creates one Satellite Absorption Component (SAC). In the Cool Extended Envelope there are the density regions which create the emission components and the narrow absorption components. The emission regions move radially with 20 km/s and create SACs with Full Width at Half Maximum (FWHM) about 7.1 Å. In 7 of the 120 stars where we detected one more emission region, with the same radial velocity and FWHM about 2.0 Å. The narrow absorption components have FWHM about 2.0 Å and the regions which create them have radial velocity of 0 km/s.

The profiles of the studied Hα lines appear to be peculiar and complex, as they do not present only one spectral line, but a number of SACs, which are created in independent density regions. All the studied stars do not present the same number of independent density regions.

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The flux ratio of the [OIII] λ λ 4959, 5007 Å lines in AGN

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Abstract. Up to now, all direct observational checks of the theoretical [OIII] 5006.843/4958.511 intensity ratio have been made for photoionized gaseous nebulae spectra. However, in some papers analyzing spectra of quasars, galaxies and AGN, this ratio is obtained as by-product, used as a checking method or may be derived from published results. Recently, taking into account relativistic corrections to the magnetic dipole operator, Storey and Zeippen obtained the line intensity ratio of 2.98. In order to check that new value using the AGN spectra, we present the measurements of flux ratio of [OIII] λ λ 4959, 5007 Å emission lines for a sample of 62 AGN, obtained from SDSS Database and from the published observations. We selected the sample using criteria of high signal to noise ratio and that line shapes of 4959 and 5007 are the same. We found that flux ratio is 2.993 ± 0.014, which is in a good agreement with the theoretical value of 2.98 given by Storey and Zeippen (2000).

Keywords: AGN, NLR, line profiles, [OIII] lines, flux ratio
PACS: 95.30.Ky, 98.54.Cm, 95.75.Fg, 98.62.Ra

INTRODUCTION

The pair of the forbidden [OIII] λ λ 4958.911, 5006.843 Å spectral emission lines observed in emission nebulae and Active Galactic Nuclei (AGN) offer themselves to: (a) test observationally the accuracy of theoretical calculations from atomic theory; (b) check the linearity of the detectors in use; (c) eventually test assumptions on the target physics under extreme circumstances (optical thickness effect). They are very strong in the spectra of photoionized nebulae as well as in the spectra of the Narrow Line Region (NLR) photoionized gas surrounding the accreting super massive black hole in the center of an AGN. The considered transitions are strongly forbidden for electric dipoles by the Laporte rule, so that they are electric quadripole or magnetic dipole ones [1].

Since transitions are strongly forbidden and since both lines originate from the same lower and slightly different upper energy levels, both lines may be scaled to exactly the same emission line profile. Their flux ratios depend only on atomic properties - the energy differences between the fine structure levels and Einstein A-coefficients. External physical condition as density, temperature and velocities, have no influence on flux ratio [2] between these two lines. Consequently, their ratio is very convenient for different tests of the linearity of observational detectors and some theoretical inovations in atomic physics.

Recently, Storey and Zeippen [3] improved the [OIII] λ λ 4959, 5007 Å flux ratio

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taking into account the higher order relativistic corrections for the magnetic dipole operator calculations, obtaining a value of 2.98, with a conclusion that this new value should be checked by observations of photoionized gaseous nebulae spectra. Namely, the previous theoretical work of Galavis et al. [4] providing a value of 2.89 was inconsistent with observational ratios obtained from spectra of photoionized gaseous nebulae, where Rosa [5] measured a flux ratio of 3.03±0.03, while measurements of Iye et al. [6] give a value of 3.17±0.04, and that of Leisy and Dennefeld [7] 3.00±0.08. In fact, up to now, all direct flux ratio measurements of the [OIII] λ λ 4959, 5007 Å lines have been made only for photoionized gaseous nebulae spectra. They can be found in some papers analyzing spectra of quasars or galaxies, but only as a by-product or as a checking method.

Our principal aim here, is to check the theoretical inovation of Storey and Zeippen (2000) by analyzing the considered lines in the spectra of AGN, and not in the photoionized gaseous nebulae spectra as was done up to now. Additionally we want to check if the [OIII] λ λ 4959, 5007 Å emission flux ratio in NLR spectra of photoionized gas surrounding black hole in the center of an AGN could be reliably used for different tests of observational equipment and new theoretical improvements.

THE SAMPLE AND MEASUREMENTS

We selected our AGN sample spectra, with high signal to noise ratio, from the latest Date Release Four (DR4) of the SDSS Database and from observations described in paper of Marziani et al. [8]. We subtracted the continuum by using DIPSO software, and in some spectra we subtracted the Hâ and FeII emission lines which contaminate the [OIII] λ λ 4959, 5007 Å lines.

After that we compared the [OIII] λ λ 4959, 5007 Å line profiles (see Figs. 1-3) by DIPSO software and we selected our initial sample of 62 AGN by using the criteria that the shapes of 5007 and 4959 lines are the same or different in a small percent.

From the initial sample of 62 AGN, a number of 32 AGN satisfies the criteria that the line profiles of the both [OIII] lines are identical (Fig. 1). The rest of spectra have slightly different line shapes (Figs. 2, 3).

We measured the flux ratio for initial sample of 62 spectra and for final sample of 32 spectra.

Here we present a histogram of the flux ratio values of the initial sample and the final sample (Fig. 4).

THE RESULTS AND CONCLUSIONS

For the initial sample of 62 objects we found flux ratio 2.992±0.014, and for the final sample of 32 AGNs a value of 2.993±0.014. The obtained flux ratios in both case are in good agreement with the value of 2.98, the improved theoretical value of Storey and Zeippen [3].

Our result confirm that the inclusion of higher order relativistic corrections for the magnetic dipole operator calculations improve the theoretical value of the [OIII] λ

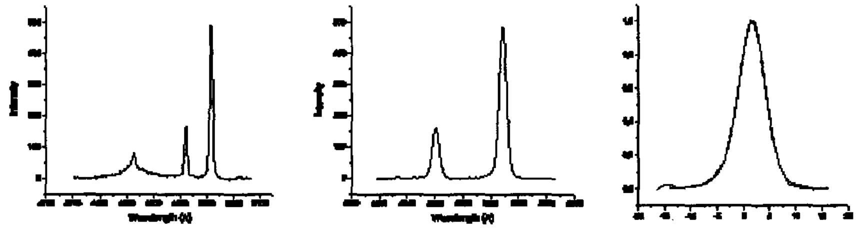


FIGURE 1. Example of the selected spectrum (SDSS J082308.29+42252000.00) with the same shapes of the [OIII] λ λ 5007 Å and 4959 Å lines. Left- observed spectrum, middle- lines without continuum and contaminating emission, right- the profile of 4959 Å line scaled to the profile of 5007 Å line.

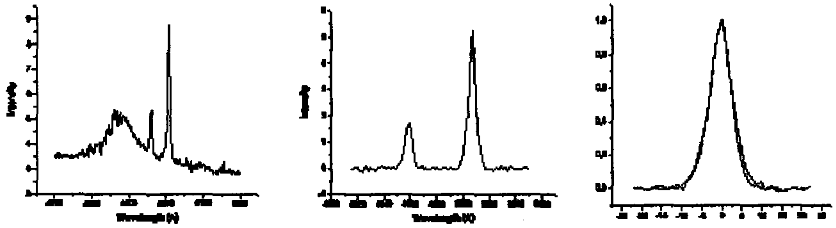


FIGURE 2. Example of the spectrum (PKS 2135-14) where the line shapes are slightly different in wings.

λ 4959, 5007 Å flux ratio which is in agreement with AGN spectra observations. Moreover, our results show that now, with the improvement of accuracy and resolution of spectral observations by using space born instruments, the [OIII] λ λ 4959, 5007 Å flux ratio from AGN spectra may be reliably used for various checks of observational detectors and theoretical calculations. This work is a part of a larger study which will be published in Ref. [9].

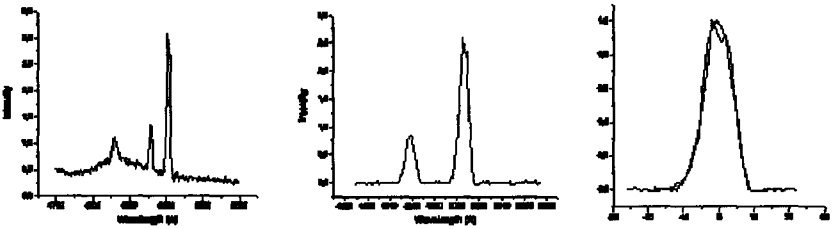
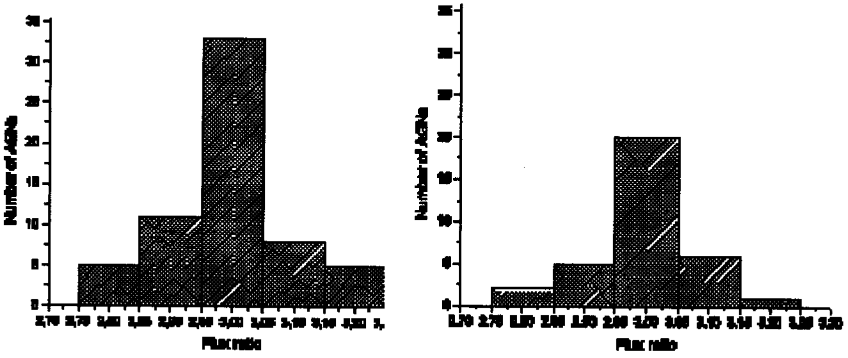


FIGURE 3. Example of the spectrum (SDSS J120114.35-0.324000.00) where the line shapes are slightly different in central part.



(a) (b)

FIGURE 4. Histogram showing the distribution of the measured flux ratio of the initial 62 AGNs sample (a), and the final sample (b)

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VAMDC - The Virtual Atomic and Molecular Data Centre - A New Way to Disseminate Atomic and Molecular Data - VAMDC Level 1 Release

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Abstract. The Virtual Atomic and Molecular Data Centre (VAMDC, http://www.vamdc.eu/) is a European-Union-funded collaboration between groups involved in the generation, evaluation, and use of atomic and molecular data. VAMDC aims to build a reliable, open, flexible and interoperable e-science interface to existing atomic and molecular data. The project will cover establishing the core consortium, the development and deployment of the infrastructure and the development of interfaces to the existing atomic and molecular databases. This paper describes the organisation of the project and the achievements during its first year.

Keywords: Atomic & molecular physics, Computing, Archives
PACS: 30, 32, 33, 34, 89.20f, 89.20h

INTRODUCTION

The Virtual Atomic and Molecular Data Centre (VAMDC[2]) is a European-Union-funded collaboration between groups involved in the generation, evaluation, and use

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[2] `http://www.vamdc.eu/`

of atomic and molecular data, as well as in the technical development and use of key e-infrastructures (e.g. the Euro-VO[3]) and the European Grid Initiative[4]. The authors of [1] constitute the core partners of the project. The VAMDC e-Infrastructure involves 15 legal institutes from 6 European Union member states, partners in non-EU countries (the Russian Federation, Serbia and Venezuela) and external partners in the US. It is a 42-month project that started on 1 July 2009.

VAMDC aims to build a reliable, open, flexible and interoperable e-science interface to existing atomic and molecular data. Initially, the core of the VAMDC e-infrastructure is based on the databases detailed in [1]; VAMDC welcomes the addition of other database resources in due course. VAMDC key objectives are 1) to implement VAMDC interface for accessing major existing databases containing heterogeneous data and aimed at different users, 2) to enable data queries across multiple databases that are focussed on specific research topics, 3) to enable data publishing/quality control process for major Atomic and Molecular (A&M) data-producers, 4) to involve wide user and producer communities in development and use of VAMDC. User communities include astrophysics, atmospheric sciences, plasma physics, combustion media to lighting and etching industries, with various approaches such as simulations, observations and diagnostics.

The project is organized in Networking activities, Service Activities and Joint Research Activities whose objectives are described in the following sections together with the achievements during the first year.

NETWORKING ACTIVITIES (NAs)

Objectives

The NAs foster a culture of cooperation between A&M scientists, database providers and data users throughout Europe. Three work packages (WP) are active: WP1 for internal management of VAMDC, including financial control of the project, reporting to the EU, and formal packaging of deliverables; and two NAs. NA1 provides the scientific and technical direction necessary for the development of the VAMDC e-infrastructure, while NA2 provides the links between VAMDC and the wider user community, being responsible for training and dissemination.

Achievements during Year 1

NA1 has focussed on coordination with key external standards groups such as the International Virtual Observatory [5], the XSAMS group [6], and EGI; and on coordina-

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NA2 has established links worldwide in Asia, Russia, South America, USA and within many different communities of producers and users of A&M data. Details of all presentations to the community can be found on the VAMDC web-site. [10]

SERVICE ACTIVITIES (SAs)

Objectives

The key objective of the SAs is to provide access to an inclusive range of high quality data and applications services to the research community. The VAMDC partners represent major data producers. The SAs make these data available on the WWW in a consistent and supported form.

SA1, Infrastructure Deployment, establishes web services at the sites of VAMDC partners. These services provide access to A&M databases; supply metadata informing the use of those databases; and allow higher-order data products to be derived from the archived data by execution of applications at the archive site. Where a partner holds data that are not in a suitable form for remote querying, SA1 assists in the creation of suitable databases. Further, where a small data-producer does not want to run their own database, SA1 can arrange for hosting of those data and services at a VAMDC site. SA1 also provides a web portal and desktop utilities for access to the services.

SA2, Support to Infrastructure, supports the operation of the services deployed by SA1. Email support is available both to data producers and to scientists using the data. SA2 monitors the health of the deployed services. Some support is available for users who want to adapt their own software to the grid. Since VAMDC makes A&M data from different sources more easily comparable, SA2 is able to assess quality by looking for discrepancies between database.

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A level-1 infrastructure was release, including a registry service for the metadata and services for a selected set of databases which served as a test of the technology. The

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data services respond to database queries and emit data extracts in the XSAMS format. Monitoring of the deployed services is operational. VAMDC beta-testers can access the grid at Paris Observatory.

In Year 2, there will be a level-2 release with data services for all data-sets held by VAMDC partners and some prototypes of the derived-data services. SA2 will arrange access to EGI for VAMDC users and will start the quality assessment of the data.

JOINT RESEARCH ACTIVITIES (JRAs)

Objectives

The Joint Research Activities build the complete set of "tools" necessary to create the VAMDC infrastructure, creating new specifications and creating/adapting/integrating new software. All the VAMDC software and supporting libraries will be available under free-software licenses.

JRA1, Interoperability, defines standards necessary to build a consistent infrastructure. It specifies data models, query languages, service protocols and dictionaries of standard terms.

JRA2, Publishing Tools, provides the software by which SA1 can deploy archive-data services for data producers. The tools cover generation of relational databases from ASCII files and the web services that respond to remote queries on those databases, following the standards developed by JRA1.

JRA3, New Mining and Integration Tools, develops software for cross-matching and cross-federation of heterogeneous resources and application services wrapping complex work flows combining AM data access, manipulation, and integration into user processing chains.

Achievements during Year 1

JRA1 has prototyped new schemata for the molecular part of XSAMS. These extensions proved very useful in the design of VAMDC services and shall become part of the XSAMS core during 2011. A separate data model has been developed for solid spectroscopy which is not totally included in XSAMS.

JRA1 has defined the TAP-XSAMS protocol for data services. This extends the IVOA Table Access Protocol with the XSAMS data-model for A&M data and the query language VAMDC SQL sub-set 1 (VSS1). VSS1 in turn uses the standard names established in the VAMDC Dictionary.

JRA2 has developed two prototypes of the publishing tools, investigating the benefits of different languages and libraries and of two different approaches to the development.

The first prototype is designed to be reusable at many VAMDC sites. It is flexible and can be configured to suit an existing database, but also includes the code to generate its own database from data in ASCII files. The adaptability comes from the use of the Django framework for web-services and the software is therefore written in Python.

The second prototype is written specifically for the BASECOL database, in Java. The code is co-developed with the database (the database was given extra tables to better support XSAMS) and aims for efficiency rather than adaptability to other data-sets. Figure 1 shows the internal architecture of this service. Initially, the service was implemented with specialized, Java code that depends on the structure of the BASECOL database. That approach allowed a working prototype to be quickly developed but left much code to be maintained. The hand-written code has been progressively replaced with a data-access layer generated, by tooling, from the database schema. This refinement takes longer to achieve but makes maintenance much easier.

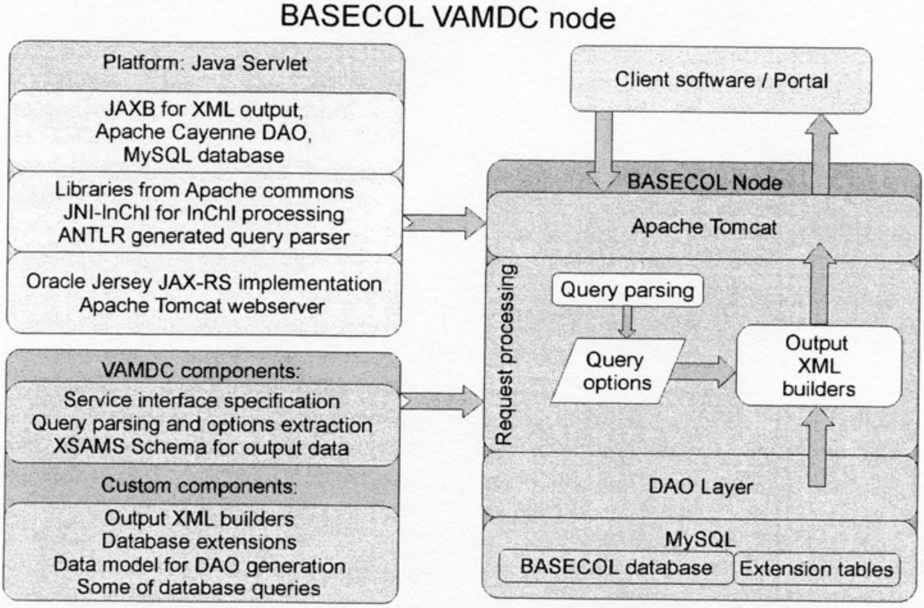


FIGURE 1: Internal architecture of BASECOL archive-data service for VAMDC standards. The client/portal component is a separate installation and is not specific to BASECOL.

Both prototypes are considered successful and are used in the level-1 release. The BASECOL prototype proves that it is feasible for publishers to write a local implementation of the VAMDC standards. The Dango-based prototype proves that it is possible for VAMDC to provide code to data producers that can be adapted to their data sets with little extra development. In year 2, the Django-based software will be refined and released to data producers. The BASECOL service-software will be made available as a guide to local development.

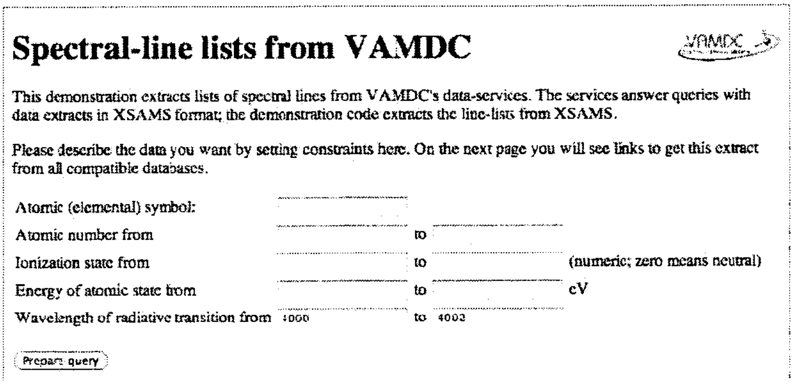
JRA3 has focused on designing a tool for handling XSAMS outputs. This is a useful 'user test-bench' for the evaluation of the standards in JRA1, and a refined version will be released in year 2. Specification have been prepared for a tool allowing handling both gas phase and solid spectroscopy for planetology and interstellar medium applications, to be built in year 2.

VAMDC LEVEL 1 RELEASE

The level-1 release provides archive-data services for a selection of databases: VALD [2], XstarDB [3], BASECOL [4, 5], CDMS [6]. A registry of metadata and a web portal support these services. There is also a 'broker' service, following the Simple Line Access Protocol of IVOA, that combines data from all the archive services.

The set of databases is deliberately restricted in the level-1 release. The level-2 release, planned for 2011, will connect far more data-sets, including CHIANTI [7], eMOL [8], GhoSST [9], HITRAN [10], SPECTRW [11], SMPO [12], TOPbase [13], UDfA [14] and a database of polycyclic hydrocarbons [15].

Users are able to investigate the level-1 release using the provided web-portal, and could also use the services in their own application. To prove the latter approach, we produced a simple web-site that generates spectral-line lists from the XSAMS output of the archive services and presents them as web pages in HTML. Figure 2 shows the query form and Fig. 3 the results.



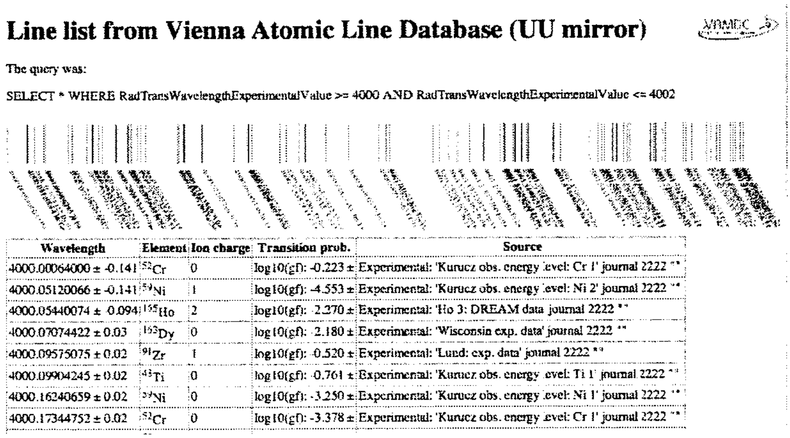
Spectral-line lists from VAMDC

This demonstration extracts lists of spectral lines from VAMDC's data-services. The services answer queries with data extracts in XSAMS format; the demonstration code extracts the line-lists from XSAMS.

Please describe the data you want by setting constraints here. On the next page you will see links to get this extract from all compatible databases.

Atomic (elemental) symbol:
Atomic number from to
Ionization state from to (numeric; zero means neutral)
Energy of atomic state from to eV
Wavelength of radiative transition from 4000 to 4002

FIGURE 2: Query form for spectral-line application



Line list from Vienna Atomic Line Database (UU mirror)

The query was:

SELECT * WHERE RadTransWavelengthExperimentalValue >= 4000 AND RadTransWavelengthExperimentalValue <= 4002

Wavelength	Element	Ion charge	Transition prob.	Source
4000.00064000 ± -0.141	^{52}Cr	0	log10(gf): -0.223 ±	Experimental: 'Kurucz obs. energy level: Cr 1' journal 2222 ""
4000.05120066 ± -0.141	^{59}Ni	1	log10(gf): -4.553 ±	Experimental: 'Kurucz obs. energy level: Ni 2' journal 2222 ""
4000.05440074 ± -0.094	^{165}Ho	2	log10(gf): -2.270 ±	Experimental: 'Ho 3: DREAM data journal 2222 ""
4000.07074422 ± 0.03	^{162}Dy	0	log10(gf): -2.180 ±	Experimental: 'Wisconsin exp. data' journal 2222 ""
4000.09575075 ± 0.02	^{91}Zr	1	log10(gf): -0.520 ±	Experimental: 'Lund: exp. data' journal 2222 ""
4000.09904245 ± 0.02	^{43}Ti	0	log10(gf): -0.761 ±	Experimental: 'Kurucz obs. energy level: Ti 1' journal 2222 ""
4000.16240659 ± 0.02	^{59}Ni	0	log10(gf): -3.250 ±	Experimental: 'Kurucz obs. energy level: Ni 1' journal 2222 ""
4000.17344752 ± 0.02	^{52}Cr	0	log10(gf): -3.378 ±	Experimental: 'Kurucz obs. energy level: Cr 1' journal 2222 ""

FIGURE 3: Visualization of spectral-line output from VALD.

This exercise show the power of the XSAMS format. All necessary information is contained in the XSAMS structure and, because that structure is XML, the web presentation of the line-list, including the graphics, can be generated from the XSAMS using a stylesheet; because the presentation detail is captured in the stylesheet, the rest of the web site needs little data-handling code and is only 137 statements in Java. The stylesheet can easily be changed to provide a different view of the data, or to transcribe selected data into formats other then HTML.

To test the transcription of XSAMS into machine-readable formats, we used the broker service implementing IVOA's Simple Line Access Protocol (SLAP). This service reformats the SLAP query into VAMDC's VSS1 query-language, forwards the query to the VAMC archive services and translates the results into IVOA's format using a stylesheet. Both translations proved straightforward to write.

In year 1, the release is only available to selected beta-testers within VAMDC. The level-2 release in 2011 will be more widely available.

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[9] `http://www.europlanet-eu.org/`

[10] `http://voparis-twiki.obspm.fr/twiki/bin/view/VAMDC/TalksVamdc`

data services respond to database queries and emit data extracts in the XSAMS format. Monitoring of the deployed services is operational. VAMDC beta-testers can access the grid at Paris Observatory.

In Year 2, there will be a level-2 release with data services for all data-sets held by VAMDC partners and some prototypes of the derived-data services. SA2 will arrange access to EGI for VAMDC users and will start the quality assessment of the data.

JOINT RESEARCH ACTIVITIES (JRAs)

Objectives

The Joint Research Activities build the complete set of "tools" necessary to create the VAMDC infrastructure, creating new specifications and creating/adapting/integrating new software. All the VAMDC software and supporting libraries will be available under free-software licenses.

JRA1, Interoperability, defines standards necessary to build a consistent infrastructure. It specifies data models, query languages, service protocols and dictionaries of standard terms.

JRA2, Publishing Tools, provides the software by which SA1 can deploy archive-data services for data producers. The tools cover generation of relational databases from ASCII files and the web services that respond to remote queries on those databases, following the standards developed by JRA1.

JRA3, New Mining and Integration Tools, develops software for cross-matching and cross-federation of heterogeneous resources and application services wrapping complex work flows combining AM data access, manipulation, and integration into user processing chains.

Achievements during Year 1

JRA1 has prototyped new schemata for the molecular part of XSAMS. These extensions proved very useful in the design of VAMDC services and shall become part of the XSAMS core during 2011. A separate data model has been developed for solid spectroscopy which is not totally included in XSAMS.

JRA1 has defined the TAP-XSAMS protocol for data services. This extends the IVOA Table Access Protocol with the XSAMS data-model for A&M data and the query language VAMDC SQL sub-set 1 (VSS1). VSS1 in turn uses the standard names established in the VAMDC Dictionary.

JRA2 has developed two prototypes of the publishing tools, investigating the benefits of different languages and libraries and of two different approaches to the development.

The first prototype is designed to be reusable at many VAMDC sites. It is flexible and can be configured to suit an existing database, but also includes the code to generate its own database from data in ASCII files. The adaptability comes from the use of the Django framework for web-services and the software is therefore written in Python.

The second prototype is written specifically for the BASECOL database, in Java. The code is co-developed with the database (the database was given extra tables to better support XSAMS) and aims for efficiency rather than adaptability to other data-sets. Figure 1 shows the internal architecture of this service. Initially, the service was implemented with specialized, Java code that depends on the structure of the BASECOL database. That approach allowed a working prototype to be quickly developed but left much code to be maintained. The hand-written code has been progressively replaced with a data-access layer generated, by tooling, from the database schema. This refinement takes longer to achieve but makes maintenance much easier.

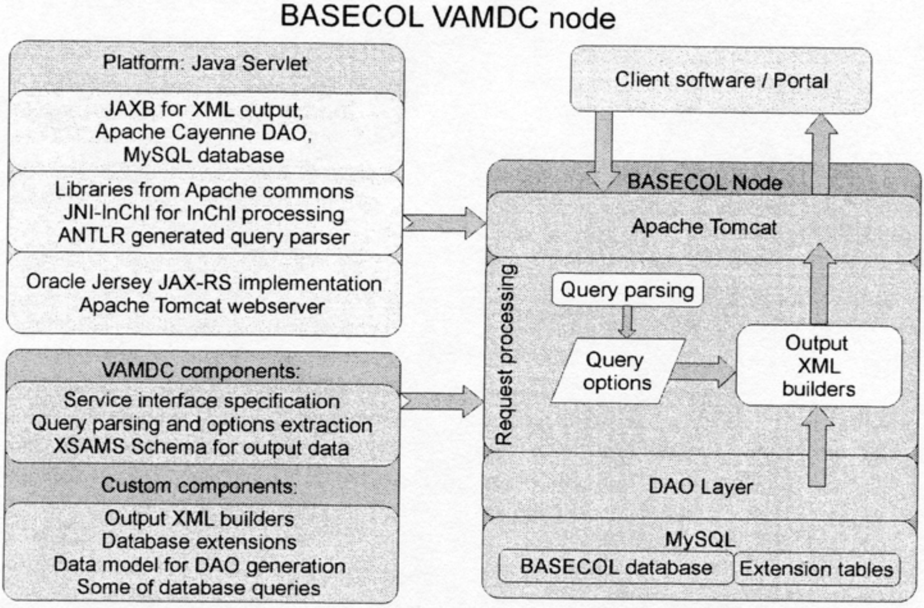


FIGURE 1: Internal architecture of BASECOL archive-data service for VAMDC standards. The client/portal component is a separate installation and is not specific to BASECOL.

Both prototypes are considered successful and are used in the level-1 release. The BASECOL prototype proves that it is feasible for publishers to write a local implementation of the VAMDC standards. The Dango-based prototype proves that it is possible for VAMDC to provide code to data producers that can be adapted to their data sets with little extra development. In year 2, the Django-based software will be refined and released to data producers. The BASECOL service-software will be made available as a guide to local development.

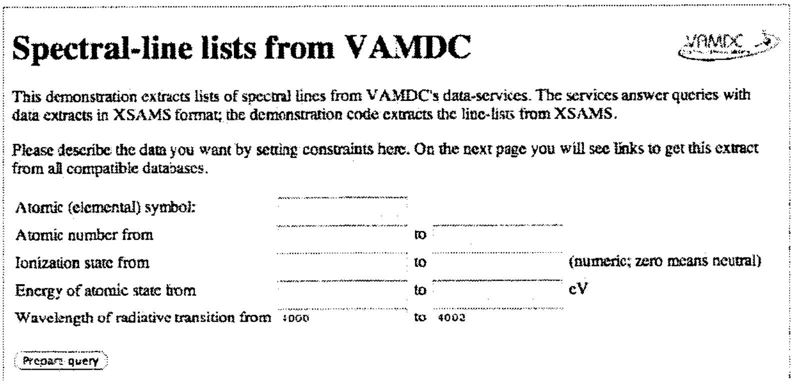
JRA3 has focused on designing a tool for handling XSAMS outputs. This is a useful 'user test-bench' for the evaluation of the standards in JRA1, and a refined version will be released in year 2. Specification have been prepared for a tool allowing handling both gas phase and solid spectroscopy for planetology and interstellar medium applications, to be built in year 2.

VAMDC LEVEL 1 RELEASE

The level-1 release provides archive-data services for a selection of databases: VALD [2], XstarDB [3], BASECOL [4, 5], CDMS [6]. A registry of metadata and a web portal support these services. There is also a 'broker' service, following the Simple Line Access Protocol of IVOA, that combines data from all the archive services.

The set of databases is deliberately restricted in the level-1 release. The level-2 release, planned for 2011, will connect far more data-sets, including CHIANTI [7], eMOL [8], GhoSST [9], HITRAN [10], SPECTRW [11], SMPO [12], TOPbase [13], UDfA [14] and a database of polycyclic hydrocarbons [15].

Users are able to investigate the level-1 release using the provided web-portal, and could also use the services in their own application. To prove the latter approach, we produced a simple web-site that generates spectral-line lists from the XSAMS output of the archive services and presents them as web pages in HTML. Figure 2 shows the query form and Fig. 3 the results.



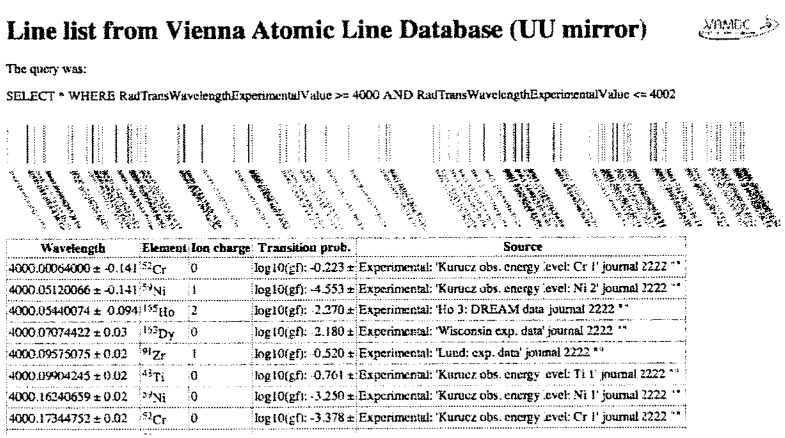
Spectral-line lists from VAMDC

This demonstration extracts lists of spectral lines from VAMDC's data-services. The services answer queries with data extracts in XSAMS format; the demonstration code extracts the line-lists from XSAMS.

Please describe the data you want by setting constraints here. On the next page you will see links to get this extract from all compatible databases.

Atomic (elemental) symbol:
Atomic number from to
Ionization state from to (numeric; zero means neutral)
Energy of atomic state from to eV
Wavelength of radiative transition from 4000 to 4002

FIGURE 2: Query form for spectral-line application



Line list from Vienna Atomic Line Database (UU mirror)

The query was:

SELECT * WHERE RadTransWavelengthExperimentalValue >= 4000 AND RadTransWavelengthExperimentalValue <= 4002

Wavelength	Element	Ion charge	Transition prob.	Source
4000.00064000 ± -0.141	^{52}Cr	0	log10(gf): -0.223 ±	Experimental: 'Kurucz obs. energy level: Cr 1' journal 2222 ""
4000.05120066 ± -0.141	^{58}Ni	1	log10(gf): -4.553 ±	Experimental: 'Kurucz obs. energy level: Ni 2' journal 2222 ""
4000.05440074 ± -0.094	^{165}Ho	2	log10(gf): -2.270 ±	Experimental: 'Ho 3: DREAM data journal 2222 ""
4000.07074422 ± 0.03	^{162}Dy	0	log10(gf): -2.180 ±	Experimental: 'Wisconsin exp. data' journal 2222 ""
4000.09575075 ± 0.02	^{91}Zr	1	log10(gf): -0.520 ±	Experimental: 'Lund: exp. data' journal 2222 ""
4000.09904245 ± 0.02	^{48}Ti	0	log10(gf): -0.761 ±	Experimental: 'Kurucz obs. energy level: Ti 1' journal 2222 ""
4000.16240659 ± 0.02	^{58}Ni	0	log10(gf): -3.250 ±	Experimental: 'Kurucz obs. energy level: Ni 1' journal 2222 ""
4000.17344752 ± 0.02	^{52}Cr	0	log10(gf): -3.378 ±	Experimental: 'Kurucz obs. energy level: Cr 1' journal 2222 ""

FIGURE 3: Visualization of spectral-line output from VALD.

This exercise show the power of the XSAMS format. All necessary information is contained in the XSAMS structure and, because that structure is XML, the web presentation of the line-list, including the graphics, can be generated from the XSAMS using a stylesheet; because the presentation detail is captured in the stylesheet, the rest of the web site needs little data-handling code and is only 137 statements in Java. The stylesheet can easily be changed to provide a different view of the data, or to transcribe selected data into formats other then HTML.

To test the transcription of XSAMS into machine-readable formats, we used the broker service implementing IVOA's Simple Line Access Protocol (SLAP). This service reformats the SLAP query into VAMDC's VSS1 query-language, forwards the query to the VAMC archive services and translates the results into IVOA's format using a stylesheet. Both translations proved straightforward to write.

In year 1, the release is only available to selected beta-testers within VAMDC. The level-2 release in 2011 will be more widely available.

ACKNOWLEDGMENTS

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The Project for the Determination of Stark Broadening Parameters within the Modified Semiempirical Approach: Ag II

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Abstract. Investigations of the Stark line broadening parameters are important for a number of problems in laboratory and astrophysical plasma research. We use a modified semiempirical approach in order to complete a set of the Stark broadening data. Here we present the Stark broadening data for 6 Ag II spectral lines calculated within the modified semiempirical approach.

INTRODUCTION

Investigations of the Stark line broadening parameters are important for a number of problems in laboratory and astrophysical plasma research as e.g. analysis and synthesis of stellar spectra and modeling of stellar atmospheres and spectra. The Belgrade group (M. S. Dimitrijević, L. Č. Popović, V. Kršljanin, D. Tankosić and N. Milovanović) uses the modified semiempirical approach [1] in order to complete as much as possible the existing set of the Stark broadening data available to users in physics and astrophysics. The modified semiempirical approach is used in the case when the energy level data, needed for the reliable full semiclassical calculation, are not completed sufficiently. Up to now, this group has performed Stark broadening parameter calculations for Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, La II, Au II ,Eu II,Ti II, Kr II, Na II ,Y II, Zr II, Sc II, Ra II, Be III, B III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III, La III, V III, Ti III, Bi III, Sr III, Cu III, Co III, Zr III, B IV, Cu IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, NeV, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI and Cl VI spectral lines [see e.g. Ref. 2 and references therein], using the modified semiempirical approach.

Also, considering that Au II λ=174.048nm, Co II λ=230.785nm and Ti II λ=376.132nm lines have been used for gold, cobalt and titanium abundance determination (see e.g. Refs. 3, 4 for gold, Ref. 5 for cobalt and Ref. 6 for titanium) in HgMn stars, this group has tested the influence of Stark broadening mechanism on equivalent widths of these lines for an A type star atmosphere, as well as for DA and DB white dwarfs [7]. This has been done with the help of Kurucz's model atmospheres

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[8] of an A type star (T_{eff}=10000K, log g=4), and with Wickramasinghe's models of DA (T_{eff}=10000K, log g=6) and DB (T_{eff}=15000K, log g=7) white dwarf atmospheres [9].

RESULTS AND DISCUSSION

There is not neither experimental nor theoretical Stark broadening data for singly charged Ag in lines except for the $4d^{10}$ ^1S-$5p^1P^o$ resonant Ag II spectral line where Stark-broadening data have been estimated, based on regularities and systematic trends [10]. Here we present the Stark broadening data for 6 Ag II spectral lines calculated within the modified semiempirical approach. Calculations were performed for an electron density of 10^{23} m^{-3}, within the temperature range 5000-50000 K. Energy level data were taken from [11]. Oscillator strengths have been calculated by using the method of Bates and Damgaard [12]. In Table 1 the Stark broadening parameters for the 6 Ag II spectral lines, as a function of temperature, are shown.

TABLE 1. The Stark broadening parameters for 6 Ag II spectral lines, as a function of temperature, at an electron density of 10^{23} m^{-3}.

Transition	T(K)	W(nm)	d (nm)
$5s^1D_2 - 5p^2P_1^0$ λ=228.07 nm	5000	0.659E-02	-0.127E-03
	10000	0.459E-02	-0.812E-04
	20000	0.318E-02	-0.440E-04
	30000	0.256E-02	-0.237E-04
	40000	0.221E-02	-0.926E-05
	50000	0.199E-02	0.399E-05
$5s^1D_2 - 5p^2D_2^0$ λ=223.03 nm	5000	0.657E-02	-0.134E-03
	10000	0.458E-02	-0.871E-04
	20000	0.317E-02	-0.500E-04
	30000	0.256E-02	-0.304E-04
	40000	0.221E-02	-0.158E-04
	50000	0.200E-02	-0.441E-05
$5s^1D_2 - 5p^2F_2^0$ λ= 232.10 nm	5000	0.694E-02	-0.308E-03
	10000	0.483E-02	-0.214E-03
	20000	0.335E-02	-0.144E-03
	30000	0.270E-02	-0.112E-03
	40000	0.234E-02	-0.894E-04
	50000	0.211E-02	-0.747E-04
$5p^1P_1^0 - 6s^1D_2$ λ= 281.61nm	5000	0.154E-01	-0.435E-02
	10000	0.108E-01	-0.315E-02
	20000	0.745E-02	-0.234E-02
	30000	0.601E-02	-0.201E-02
	40000	0.518E-02	-0.183E-02
	50000	0.466E-02	-0.172E-02

TABLE 1 - continued.

Transition	T(K)	W(nm)	d (nm)
$5p\,^1D_2^0 - 6s\,^1D_2$ λ= 289.71 nm	5000	0.168E-01	-0.459E-02
	10000	0.117E-01	-0.333E-02
	20000	0.809E-02	-0.247E-02
	30000	0.653E-02	-0.212E-02
	40000	0.564E-02	-0.193E-02
	50000	0.508E-02	-0.181E-02
$5p\,^1F_3^0 - 6s\,^1D_2$ λ=275.71 nm	5000	0.149E-01	-0.391E-02
	10000	0.104E-01	-0.283E-02
	20000	0.722E-02	-0.210E-02
	30000	0.583E-02	-0.180E-02
	40000	0.503E-02	-0.164E-02
	50000	0.453E-02	-0.153E-02

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Stark Widths and Shifts of the Kr III Spectral Lines

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Abstract. Stark widths and shifts of eleven doubly charged (Kr III) krypton ion spectral lines have been measured in the linear, low pressure, pulsed arc at 17 000 K electron temperature and 1.65×10^{23} m^{-3} electron density. The measured width and shift values have been compared to the theoretical data calculated by us by using the modified semiempirical method.

INTRODUCTION

For the first time with the help of the Goddard high resolution spectrograph on the Hubble space telescope, krypton has been detected in the spectra of the interstellar medium [1], [2] which represents the material from which the young early type stars (as e. g. Ap and Bp type stars where Stark broadening data are of interest) are formed [3]. Moreover, krypton is present in many light sources and lasers as the working gas. In the case of the Kr III spectrum only two experiments [4], [5] deal with the Stark widths investigations of seven spectral lines. Calculations of the Kr III Stark widths have been performed in Refs. [4], [6]-[10].

Up today there is no neither reliable Stark shift measurements, nor theoretical Stark shifts for the Kr III spectral lines. In Ref. [11] Kr III line shifts have been investigated but without the reliable plasma parameter determination so that the comparison with our results is not possible.

In this work we will present measured and calculated Stark FWHM (full-width at half intensity maximum, W) and Stark shift (d) values of eleven Kr III spectral lines. Stark FWHM values of seven Kr III lines from these were not known before. The present d values of Kr III lines are the first publication with reliably determined plasma parameters in this topic.

Measurements have been performed at 17 000 K electron temperature and 1.65×10^{23} m^{-3} electron density in krypton plasma created in the linear, low pressure pulsed arc discharge [12-15]. The W and d values have been calculated within the frame of the modified semiempirical method [6, 16-22] for the electron temperature range between 10 000 K and 70 000 K.

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DISCUSSION

The needed atomic energy levels for Kr III have been taken form Ref. [23]. In the case of the Kr III spectral lines (Table 1 and Fig. 1) one can conclude that our measured (Wm) and calculated (Wth) values show very good mutual agreement (Wm/Wth ratios in Table 1). Absence of the knowledge of the complete set of perturbing energy levels in the case of the 5s"-5p" and 4d"-5p" transitions make the calculations of W values possible only within the frame of the Simplified semiempirical method [6]. Experimental Stark FWHM values from Ref. [4] agree with our calculated values (and with those from Ref. [9]) within few percents. Contrary, the measured W values from Ref. [5] lie above our (and Ref. [9]) results (see in Fig. 1 results for the 5s $^5S^0$ - 5p ^5P multiplet), especially around the electron temperature of 40 000 K, up to the factor 2. It should be pointed out that the theoretical W values [10], calculated by using the quasiclassical Gaunt factor method [24], [25], show agreement with our calculations. Calculations in Ref [10] have been performed only for the plasma conditions for experiments in Ref. [5] and the results are given only for electron temperatures higher than 37 000 K. The possible reasons for disagreement between measurements from Ref. [5] and calculations from Ref. [10] have been discussed in detail in Ref. [5].

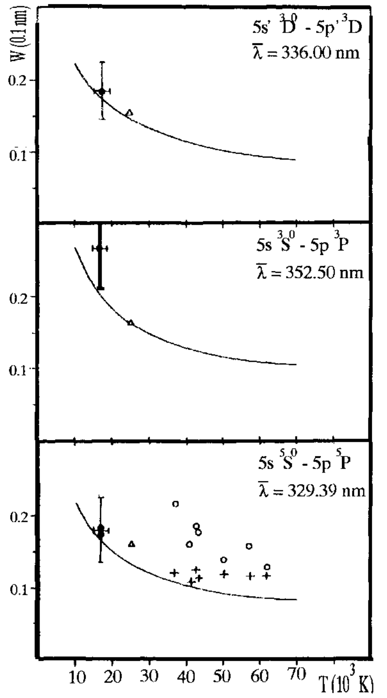

FIGURE 1. Stark FWHM (W) dependence on the electron temperature for the most investigated Kr III spectral lines belonging to the 5s-5p and 5s'-5p' transition at 1x1023 m-3 electron density. —, our calculations by using the modifed semiempirical approach. •, our experimental results and those of other authors: Δ, Ref. [4] and o, Ref. [5]. +, calculations by using the quasiclassical Gaunt factor method [10] performed only for the plasma parameters observed in the experiment in Ref. [5]. The error bars include the uncertainties of the width, electron density and temperature measurements.

In the case of the Kr III lines our measured and calculated Stark shift values show different signs. Calculations give negative d values while the measured shifts are positive. One can see in Table 1 that shifts of the considered Kr III spectral lines are almost an order of magnitude smaller than the corresponding widths. Consequently the mutual cancellations of important contributions are so significant that error bars of such results which might be as an upper limit around 50%

of the width value are extended to the positive shift values too. Theoretical reasons for the discrepancies between the signs of measured and calculated Kr III shifts could be the consequence of the complexity of the Kr III many electron atom and its spectrum where the neglected optically forbidden transitions might have an important influence.

TABLE 1. Measured Stark FWHM (W_m) and shift (d_m) values for the Kr III lines at an electron temperature (T) of 17 000 K and electron density (N) of 1.65×10^{23} m^{-3}. W_m/W_{th} presents the ratio between our measured (W_m) and calculated (W_{th}) values. Positive shift is toward the red.

Transition	Multiplet	λ [nm]	W_m [nm]	d_m [nm]	W_m/W_{th}
5s-5p	$^5S^0_2$-$^5P_1$	335.19	0.0308	0.0032	1.09
	$^5S^0_2$-$^5P_2$	332.58	0.0290	0.0031	1.04
	$^5S^0_2$-$^5P_3$	324.57	0.0300	0.0026	1.13
	$^3S^0_1$-$^3P_2$	350.74	0.0328	0.0020	0.99
5s'-5p'	$^3D^o_2$-$^3D_2$	343.95	0.0306	0.0021	1.01
	$^3D^o_1$-$^3F_2$	326.85	0.0261		1.20
	$^3D^o_3$-$^3F_4$	326.49	0.0214	0.0015	0.99
	$^3D^o_3$-$^3P_2$	302.44	0.0280	0.0011	0.91
5s"-5p"	$^3P^o_2$-$^3D_3$	337.49	0.0480	0.0013	1.45
	$^3P^o_2$-$^3P_2$	304.69	0.0395	0.00	1.45
4d"-5p"	$^3D^o_2$-$^3D_3$	302.23	0.0455	0.00	

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Stark Broadening Effect and Zirconium Conflict Problem

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Abstract. Using the Modified Semiempirical Method we have calculated the electron-impact widths for four singly and doubly ionized zirconium UV lines of astrophysical importance. Using the SYNTH and ATLAS9 codes for stellar atmospheres similiar to that of the HgMn star χ Lupi we have synthesized the line profiles and found equivalent widths for these lines. The influence of the Stark broadening effect on abundance determination and its contribution to the so-called "zirconium conflict" are discussed.

INTRODUCTION

Electron-impact broadening is the main pressure broadening mechanism in early-type star atmospheres [1]. The available abundance analyses show that about 10 % - 20 % of A and B type stars have abundance anomalies (CP stars). Studies of HgMn stars show that zirconium is often overabundant in these stars [2–5].

The zirconium abundance determined from Zr II lines is quite different from the abundance determined from Zr III lines in the HgMn star χ Lupi [4,5]. This is the so-called "zirconium conflict". It was supposed that this difference is probably due to a non-adequate use of theoretical stellar models, e. g., if the influence of non-LTE effects or diffusion are not taken into account [5].

RESULTS AND DISCUSSION

In order to investigate the influence of Stark broadening on the "zirconium conflict", we have calculated Stark broadening widths for two Zr II and two Zr III lines using the Modified Semiempirical Method [6,7]. These lines are: Zr II 232.47 nm ($4d5s5p\ v^2F^o_{5/2} - 4d^25s\ b^2G_{7/2}$), Zr II 193.85 nm ($4d5s5p\ v^2D^o_{3/2} - 4d^25s\ a^2D_{3/2}$), Zr III 194.105 nm ($4d^2\ {}^3P_2 - 4d5p\ {}^3P^o_2$) and Zr III 194.023 nm ($4d^2\ {}^1G_4 - 4d5p\ {}^1F^o_3$). In Table 1, the Stark widths calculated for these four spectral lines are given for an electron density of 10^{23} m^{-3} and temperatures from 5 000 K up to 50 000 K.

After calculation of the widths, we have synthesized the line profiles using the SYNTH code [8] and Kurucz's ATLAS9 code [9] for a stellar atmosphere model

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TABLE 1. Full Stark widths for two Zr II and two Zr III UV lines of astrophysical importance. The electron density is 10^{23} m^{-3}.

Spectral line	T (K)	W (10^{-2} nm)	Spectral line	T (K)	W (10^{-2} nm)
Zr II 232.47 nm	5000	1.220	Zr III 194.105 nm	5000	0.474
	10000	0.859		10000	0.332
	20000	0.626		20000	0.231
	30000	0.546		30000	0.187
	40000	0.508		40000	0.161
	50000	0.491		50000	0.144
Zr II 193.85 nm	5000	0.765	Zr III 194.023 nm	5000	0.459
	10000	0.537		10000	0.321
	20000	0.387		20000	0.224
	30000	0.333		30000	0.181
	40000	0.307		40000	0.156
	50000	0.294		50000	0.140

($T_{\rm eff}$ = 10 000 K, log g = 4.0) which is similiar to the atmosphere of the χ Lupi star ($T_{\rm eff}$ = 10 650 K, log g = 3.8 [10]). In Table 2 we present the ratios of the equivalent widths (EW) for the two Zr II and the two Zr III lines calculated with and without Stark broadening as a function of zirconium abundance.

TABLE 2. The ratio of equivalent widths for two Zr II and two Zr III spectral lines calculated with and without Stark broadening as a function of zirconium abundance.

$\log(N_{\rm Zr}/N_{\rm H})$	Zr II 232.47 nm	Zr II 193.85 nm	Zr III 194.023 nm	Zr III 194.105 nm
-6.0	1.062	1.073	1.172	1.211
-6.5	1.032	1.038	1.099	1.136
-7.0	1.017	1.019	1.049	1.073
-7.5	1.009	1.010	1.023	1.035
-8.0	1.005	1.006	1.012	1.017

As one can see from Table 2, the electron-impact broadening effect is more important in the case of higher zirconium abundance. The EW increases with zirconium abundance for all lines, but the EW is more sensitive for Zr III lines than for Zr II lines. This may cause errors in abundance determination if the Stark broadening effect is not taken into account. The zirconium abundance is higher if determined from Zr III lines than from Zr II lines. Although the zirconium conflict in the HgMn star χ Lupi cannot be explained only by this effect, one should take into account that this effect may cause errors in abundance determination.

Electron-impact broadening parameters for two Zr II and 30 Zr III lines are given in Ref. [11] and are included, together with other Stark broadening parameters for various elements, in the Belgrade Astronomical Database (BELDATA), internet address http://www.aob.bg.ac.yu/BELDATA.

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On the Common Influence of Stark Broadening and Hyperfine Structure in Stellar Spectra : Mn II Lines

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Abstract. Ionized manganese lines are of interest for the analysis and modelling of stellar spectra as well as for the modelling and consideration of sub photospheric layers. Recently, a disagreement of up to 5.7 times is found between experimental and calculated Stark widths and shifts of Mn II lines. As one of possible reasons, the hfs splitting was assumed. In order to investigate the reasons for this, we performed more sophisticated calculations for two Mn II lines, by using the semiclassical perturbation theory. Moreover, we made a detailed analysis of the influence of hfs splitting on the considered experimental results. Also, the obtained results were used for the investigation of the influence of Stark broadening on Mn II spectral line profiles in DB white dwarfs. It was demonstrated the importance to take into account Stark broadening mechanism for the analysis of DB white dwarf spectra. The obtained data and conclusions are of interest for a number of problems in stellar and Solar physics, like spectrum analysis and synthesis, radiative transfer and modelling of sub photospheric layers.

Keywords: plasma; stars: lines profiles, white dwarfs
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INTRODUCTION

Spectral lines of the ionized manganese are present in stellar spectra and even a special class of chemically peculiar stars, the so called HgMn stars [see e.g. 1, 2] exists. For plasma conditions in hot star atmospheres, as Ap stars or white dwarfs, hydrogen is mainly ionized and Stark broadening is the main pressure broadening mechanism, influencing spectral line shapes. For example in [3, 4] is shown that in atmospheres of A stars exist conditions where Stark widths are larger than, or comparable with, the corresponding thermal Doppler widths. Stark broadening parameters, spectral line full width at half intensity maximum (FWHM) - W, and shift - d for 16 Mn II multiplets, are determined within the modified semiempirical approach [5, 6] in [7, 8]. Additionally, Stark widths for Mn II a^5D - z^5P^o multiplet, are obtained in [9] by using the semiclassical theory [10, 11], the modified semiempirical theory [5] and Griem's semiempirical theory [12]. Moreover, for Mn II a^7S - z^7P^o multiplet, width and shift, estimated on the basis of regularities and systematic trends, are given in [13].

In an experimental study [14] are determined Stark broadening widths and shifts for 11 Mn II lines, and a disagreement up to a factor of 5.7 with theoretical results of [7]was found. As possible reasons in [14]are given: (i) "It should be pointed out that the calcu-

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lations [7] are performed using the modified semiempirical approximation which gives, generally, lower W values than the more sophisticated semiclassical approximation." (ii) "Inclusion of the helium ions, as perturbers, in the sophisticated semiclassical theory may lead to increase of the theoretical Mn II and Mn III Stark width values in helium plasma. Future calculations in this way would be helpful."

Also, the hfs splitting is discussed in Ref. [14] and the authors emphasize that due to the large Doppler broadening they had no possibility to monitor Stark broadening of particular hfs component, but only "equivalent light intensity distribution caused by Doppler broadening."

One of the aims of this contribution is to analyze disagreement of experimental [14] and theoretical results [7], but also to investigate the influence of Stark broadening mechanism on Mn II line profiles in DB white dwarf spectra and to provide new Mn II data needed for stellar plasma analyzing and modelling. Consequently, we performed more sophisticated than in [7], calculations for six Mn II lines, by using the semiclassical perturbation theory ([15, 16, 17], see also a review of updating and innovations in [19, 18]). Additionally, ionized helium impact broadening calculations were performed and a detailed analysis of the influence of hfs splitting on the experimental results of [14] was made.

CALCULATIONS WITHIN THE SEMICLASSICAL THEORY

For the calculations, the semiclassical perturbation formalism, developed and discussed in detail in [15, 16] was used. All details of the calculations and the complete results for the Stark broadening parameters for six Mn II lines will be given in [20]. As an example of results obtained, in Table 1, electron-impact broadening parameters (full width at half maximum W and shift d) for 2 Mn II lines for perturber density of $10^{17}\mathrm{cm}^{-3}$ and temperatures from 5000 to 100000 K, are shown. In order to check the possible influence of configuration interactions on disagreement between the experiment and theory, the first set of values is calculated with the included estimated maximal contribution of forbidden transitions registered in [21]. The second set of values, denoted by ($'$), is calculated taking into account only dipoly allowed transitions, as in [7, 8] [also see 5].

In Table 2, our calculations are compared with experimental results in [14]. One can see that one part of disagreement may be explained by more sophisticated, semiclassical perturbation calculations, inclusion of configuration mixing and proton-impact broadening, but the disagreement of up to a factor of 2.39 for the width is still large.

HYPERFINE STRUCTURE - HFS

In ionized manganese spectrum the hfs splitting may influence on spectral line profiles [14, 22, 23, 24]. It is stated in [14] that it is not possible to measure the hfs components, but only the whole line profile, due to large Doppler width. Here we will consider how much the hfs splitting can affect the measured [14] Doppler and Lorentz line widths. Note here, that all hfs components of a line should be with the same Lorentz and Doppler

TABLE 1. Electron-impact broadening parameters (full width at half maximum W and shift d in [Å]) for 2 Mn II lines for perturber density of $10^{17}\mathrm{cm}^{-3}$ and temperatures from 5000 to 100000 K. The first set of values is calculated with the included estimated maximal contribution of forbidden transitions registered in [21]. The second set of values, denoted by ($'$), is calculated taking into account only dipoly allowed transitions.

Transition	T[K]	W_e[Å]	d_e[Å]	W'_e[Å]	d'_e[Å]
a ^{7}S - z ^{7}P^o 2594.5Å	5000	0.128	0.236E-03	0.141	0.924E-04
	10000	0.948E-01	-0.996E-03	0.102	-0.756E-03
	20000	0.702E-01	-0.116E-02	0.740E-01	-0.858E-03
	30000	0.598E-01	-0.956E-03	0.621E-01	-0.726E-03
	50000	0.507E-01	-0.128E-02	0.516E-01	-0.924E-03
	100000	0.435E-01	-0.118E-02	0.433E-01	-0.921E-03
a ^{5}S - z ^{5}P^o 2950.1Å	5000	0.226	-0.394E-01	0.176	-0.653E-03
	10000	0.165	-0.302E-01	0.130	-0.253E-02
	20000	0.121	-0.234E-01	0.969E-01	-0.258E-02
	30000	0.102	-0.193E-01	0.830E-01	-0.209E-02
	50000	0.884E-01	-0.168E-01	0.713E-01	-0.282E-02
	100000	0.800E-01	-0.137E-01	0.619E-01	-0.257E-02

TABLE 2. The comparison between experimental and theoretical Stark broadening parameters

Transition	W_m[Å]	d_m[Å]	$\frac{W_m}{W_{PD}}$	$\frac{d_m}{d_{PD}}$	$\frac{W_m}{W_e}$	$\frac{d_m}{d_e}$	$\frac{W_m}{W_e+W_i}$	$\frac{d_m}{d_e+d_i}$
3d^5(^{6}S)4s-3d^5(^{6}S)4p a ^{7}S - z ^{7}P^o 2594.5Å	0.182	-0.008	5.44	1.00	2.76	4.00	2.39	2.67
3d^5(^{6}S)4s-3d^5(^{6}S)4p a ^{5}S - z ^{5}P^o 2950.1Å	0.208	-0.026	4.28	2.32	1.80	1.18	1.60	0.96

widths, which depend on the conditions in the plasma.

First we simulated numerically the case where the Lorentzian (w_L) and Doppler (w_D) widths are the same, but taking different ratios between the widths and hfs splitting ($w_{L,D}/D_{hfs}$), assuming only two components in hfs. We calculated the sum of the two components and after that fit the total profile with Voigt function. As one can see in Fig. 1, this effect can lead to significant differences in the estimation of widths, but only in the case where $w_{L,D}/D_{hfs} < 3$. In the case where $w_{L,D}/D_{hfs} > 3$ this effect is negligible (the differences between measured widths of components and composite profiles are a few percentage). It is interesting that in the first case, the Doppler width can be overestimated in difference with the Lorentz width that is underestimated.

In order to simulate the influence of the hfs to the line profile, in this case we adopted the Doppler width given by [14] and Stark widths (w_{st}) given by [7]. First we assume that all of the profiles have the same widths (w_L and w_D), and after summation of the hfs components we obtained a composite profile (see Fig. 3). After that we fitted the composite profile with a Voigt one. From the best fit we obtain W_L and W_D. We found

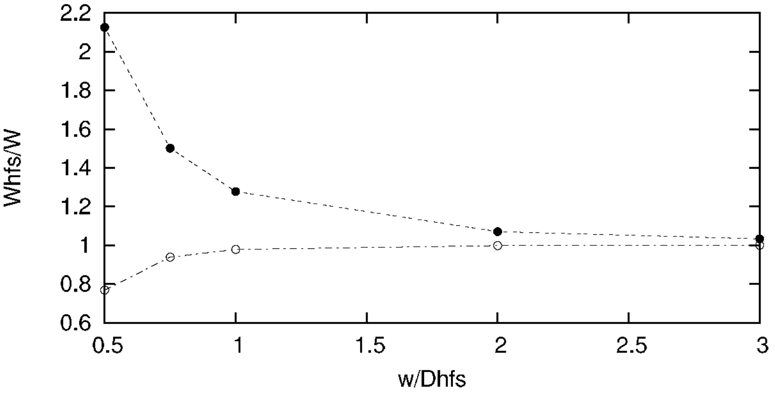

FIGURE 1. The ratio between the real widths of the hfs components W_{hfs} and determined ones measured (w_D is denoted with full, and W_L with open circles) from the composite profile, for different ratios of $w_{L,D}/D_{hfs}$ (where D_{hfs} is hfs splitting between two hfs components). The Lorentz and Doppler widths are taken to be the same.

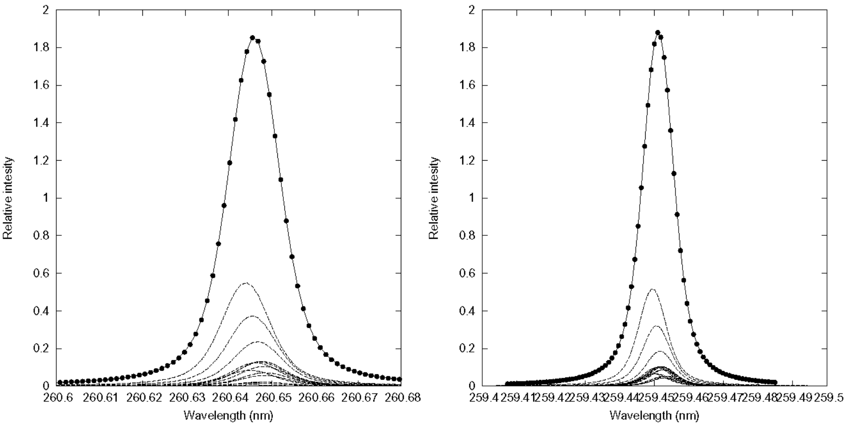

FIGURE 2. The hfs components (dashed line, below), their sum (full circles) and the best fit with the common Voigt profile (solid line) for Mn II 260.6459 nm (left) and 259.4497 nm (right). The intensity ratio of components is taken from Table 6 given in [24]

that the Doppler width is slightly larger (around 5%) and Lorentz one is slightly smaller (around 2%) than originally included in each component. Note here that the influence of hfs can affect the line shifts. In the considered cases for Mn II 260.6459 nm it is negligible, but for Mn II 259.4497 nm we found $d_{hfs} = +1.6$ pm, which is an order of magnitude of measured and calculated Stark shift for this line.

At the end, an additional test have been performed, assuming that in the case of Mn II 259.4497 nm line, each component has the Doppler width (FWHM) of 9.7 pm and Stark of 2.8 pm. Then we fixed Doppler FWHM as 5.5 pm (around 1.7 times smaller than taken in each component) and fit the composed line profile. From the fit, we obtained

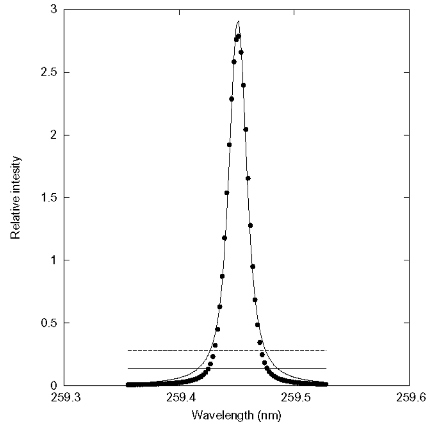

FIGURE 3. The best fit of composite line profile of Mn II 259.4497 nm where the Stark width is obtained as 2.4 times larger than was taken in each component. The horizontal lines represent the intensity at 10% (dashed line) and 5% (solid line) of maximal intensity.

that Stark width is overestimated around 2.4 times. But as can be seen in Fig. 2, there is disagreement between the best fit (solid line in the Fig. 2) and composite profile (dots in the figure) only in the wings, i.e. the part of profile with intensity smaller than 10% of maximal intensity (dashed horizontal line in the figure, solid horizontal line represents 5% of maximal intensity). Therefore, one can conclude that in the case where the line wings in experiment are not well defined/measured (e.g. a big noise in line wings), it may significantly affect the measured Stark widths.

As it can be seen from tests performed above, there is possibility that the Lorentz contribution (as well as Doppler) to the composite line profile in the case of hfs can be overestimated (underestimated). The effects of hfs on measured value of Stark width in [14] might be present. Consequently, a part of disagreement between theoretical and measured Stark broadening parameters might be due to this effect, but the question of such big differences between measured [14] and calculated [7] values of Stark width stay open.

INFLUENCE OF STARK BROADENING IN DB WHITE DWARF ATMOSPHERES

In order to investigate the importance of Stark broadening mechanism in DB white dwarf atmospheres the atmospheric models of Wickramasinghe [25], with T_{eff} = 15000 K and log g from 7 to 9, are used. Here, g is the gravitational acceleration on the stellar surface and log g=7 means that $g = 10^4$ m/s. Calculated thermal Doppler and Stark widths as a function of optical depth, for Mn II a ^{5}S - z ^{5}P^o (2950.1 Å) spectral line, are compared in Fig. 4 for DB white dwarfs. As in [25], optical depth points at the standard wavelength 5150 Åare used. As one can see, for DB white dwarf atmospheres the Stark broadening mechanism is important, especially for atmospheric layers with the optical depth larger

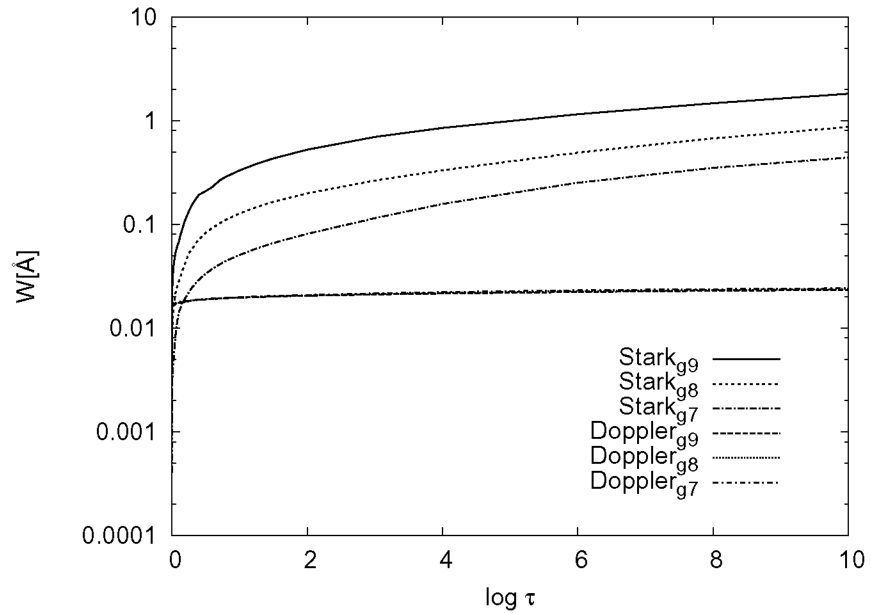

FIGURE 4. Thermal Doppler and Stark widths for Mn II spectral line a ^{5}S - z ^{5}P^o (2950.1Å) as a function of optical depth for DB white dwarf models [25]with T$_{eff}$=15000 K and log g from 7 to 9.

or approximatively equal to 0.1, where the Stark width is up to one or two orders of magnitude larger than the thermal Doppler width.

Consequently, in DB white dwarf atmospheres exist conditions, where Stark broadening is the principal broadening mechanism influencing line shape formation.

CONCLUSIONS

From our investigation one can conclude:

a) In DB white dwarf atmospheres the Stark broadening is important and should be taken into account.

b) The SC theory gives larger widths than MSE, and consequently the calculated values of Stark widths are in better agreement with experimental ones given in [14], but agreement between experiment and theory ($w_{exp}/w_{th} \approx 1.80 - 2.76$) is still not good.

c) The inclusion of proton-impact contribution, and configuration interaction effects could not explain the difference between experiment and theory ($w_{exp}/w_{th} \approx 1.60 - 2.39$).

d) The hfs effects can affect measured value of Stark widths, especially if the Doppler contribution is underestimated in fitting procedure of the composite line profile. In this case the Stark width can be significantly overestimated (e.g. Mn II 259.4497 nm), especially if the wings of measured line are with big noise.

At the end, let us stress that new measurements of Stark broadening parameters for Mn II lines are needed, especially in the plasma with lower temperature in order to explain such big differences between the experimental and theoretical values.

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Te I Stark Broadening Data for Stellar Plasma Analysis

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Abstract. In spite of the fact that tellurium is one of the least abundant element in the Earth's litosphere, its cosmic abundance is larger than for any element with atomic number greater than 40, and its spectral lines are observed in stellar spectra. Since the significance of trace element spectral data, including Stark broadening parameters, increases with the development of space-born spectroscopy, we investigate here theoretically the influence of collisions with charged particles on spectral lines of neutral tellurium. By using the semiclassical perturbation method, Stark widths and shifts of three Te I spectral lines, of interest for modellisation, investigation and diagnostic of stellar plasma have been obtained. Results were applied for the investigation of the influence of Stark broadening mechanism in ultraviolet, optical and infrared part of the spectrum of A-type star atmospheres.The obtained results demonstrate that, in the considered case, Stark broadening is more important in optical and infrared, than in the ultraviolet part of the spectrum, and that this effect should be taken into account for the considered, A-type stellar atmosphere model.

Keywords: Stark broadening; line profiles; atomic data; stellar atmospheres.
PACS: 32.70.Jz; 95.30.Ky; 97.10Ex

INTRODUCTION

Tellurium lines are of astrophysical interest due to their presence in stellar atmospheres. For example, in Ref [1], is reported, that in Procyon photosphere spectrum one line of tellurium is identified, and used to determine the abundance of this element. Here, we will calculate within the semiclassical perturbation approach [2, 3] the Stark broadening parameters of three Te I spectral lines as a function of electron density for temperatures between 2500 K and 50000 K, particularly interesting for stellar plasma investigations. The obtained results will be used for an analysis of the influence of Stark broadening in the A type stellar atmospheres.

THEORY

Calculations have been performed within the semiclassical perturbation formalism, developed and discussed in detail in [2, 3]. This formalism, as well as the corresponding computer code, have been optimized and updated several times (see e.g. [4, 5, 6]).

Within this formalism, the full width of a neutral emitter isolated spectral line, broadened by electron impacts, can be expressed in terms of cross sections for elastic and

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TABLE 1. This table shows electron-, and proton-impact broadening parameters for Te I, for a perturber density of 10^{16} cm^{-3} and temperatures from 2500 up to 50000 K. The quantity C (given in Å cm^{-3}), when divided by the corresponding full width at half maximum, gives an estimate for the maximum perturber density for which tabulated data may be used. The asterisk identifies cases for which the collision volume multiplied by the perturber density (the condition for validity of the impact approximation) lies between 0.1 and 0.5. For higher densities, the isolated line approximation used in the calculations breaks down. Here, T is the temperature, W$_e$ and W$_p$ denotes full line width at half maximum in Å, while d$_e$ and d$_p$ denotes line shift in Å.

TRANSITION	T(K)	W$_e$(Å)	d$_e$(Å)	W$_p$(Å)	d$_p$(Å)
	2500	0.387E-02	0.343E-02	0.106E-02	0.925E-03
Te I	5000	0.457E-02	0.399E-02	0.118E-02	0.107E-02
5p^4 ^{3}P - 6s ^{5}S^o	10000	0.548E-02	0.467E-02	0.133E-02	0.122E-02
(2372.7 Å)	20000	0.625E-02	0.531E-02	0.149E-02	0.138E-02
C=0.57E+19	30000	0.656E-02	0.547E-02	0.159E-02	0.149E-02
	50000	0.687E-02	0.533E-02	0.173E-02	0.162E-02
	2500	0.125	0.758E-01	*0.818E-01	*0.180E-01
Te I	5000	0.146	0.912E-01	*0.842E-01	*0.215E-01
6s ^{5}S^o - 7p ^{5}P	10000	0.170	0.944E-01	0.855E-01	0.251E-01
(5125.2 Å)	20000	0.196	0.894E-01	0.865E-01	0.288E-01
C=0.57E+19	30000	0.212	0.770E-01	0.871E-01	0.311E-01
	50000	0.230	0.638E-01	0.880E-01	0.341E-01
	2500	0.143	-0.698E-01	0.680E-01	-0.188E-01
Te I	5000	0.151	-0.808E-01	0.688E-01	-0.217E-01
6s ^{5}S^o - 6p ^{5}P	10000	0.170	-0.948E-01	0.697E-01	-0.248E-01
(9903.9 Å)	20000	0.194	-0.109	0.707E-01	-0.282E-01
C=0.99E+20	30000	0.209	-0.113	0.714E-01	-0.303E-01
	50000	0.226	-0.112	0.724E-01	-0.331E-01

inelastic processes as

$$W_{if} = 2\frac{\lambda_{if}^2}{2\pi c} n_e \int v f(v) dv \Big(\sum_{i' \neq i} \sigma_{ii'}(v) + \sum_{f' \neq f} \sigma_{ff'}(v) + \sigma_{el}\Big) \tag{1}$$

and the corresponding line shift as

$$d_{if} = \frac{\lambda_{if}^2}{2\pi c} n_e \int v f(v) dv \int_{R_3}^{R_D} 2\pi\rho\, d\rho \sin 2\phi_p \tag{2}$$

Here, λ_{if} is the wavelength of the line originating from the transition with the initial atomic energy level i and the final level f, c is the velocity of light, n_e is the electron density, $f(v)$ is the Maxwellian velocity distribution function for electrons, and ρ denotes the impact parameter of the incoming electron. The inelastic cross section $\sigma_{jj'}(v)$ is determined according to Chapter 3 in [2], and elastic cross section σ_{el} according to [2]. The cut-offs (needed for the calculation of inelastic and elastic cross sections and R_3),

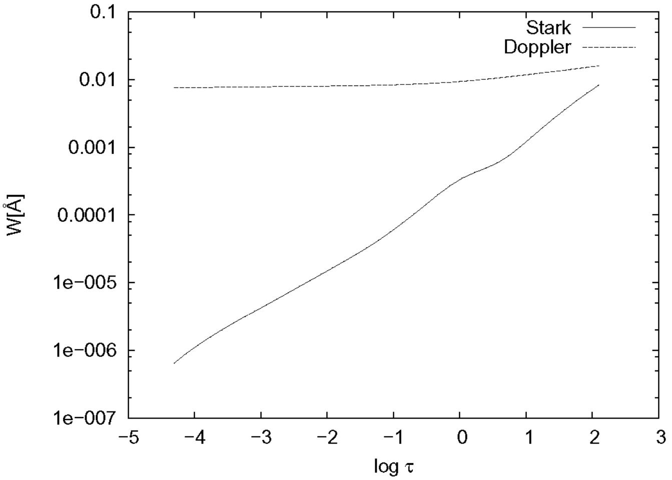

FIGURE 1. Thermal Doppler and Stark widths for Te I $5p^4\,^3$P - 6s ^{5}S^o (2372.7 Å) multiplet as functions of optical depth for an A type star (T_{eff} = 10000 K, log g = 4.5).

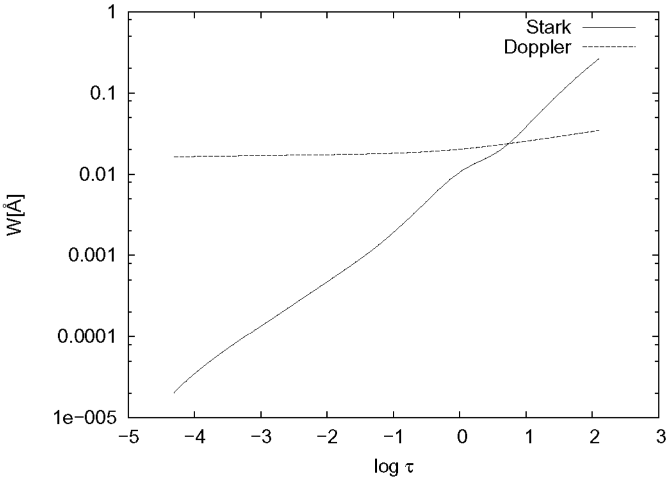

FIGURE 2. Thermal Doppler and Stark widths for Te I 6s ^{5}S^o - 7p ^{5}P (5125.2 Å) multiplet as functions of optical depth for an A type star (T_{eff} = 10000 K, log g = 4.5).

included in order to maintain for the unitarity of the S-matrix, are described in Section 1 of Chapter 3 in [2].

The formulae for the ion-impact broadening parameters are analogous to the formulae for electron-impact broadening. We note that the fact that the colliding ions would be impact in the far wings should be checked, even for stellar densities.

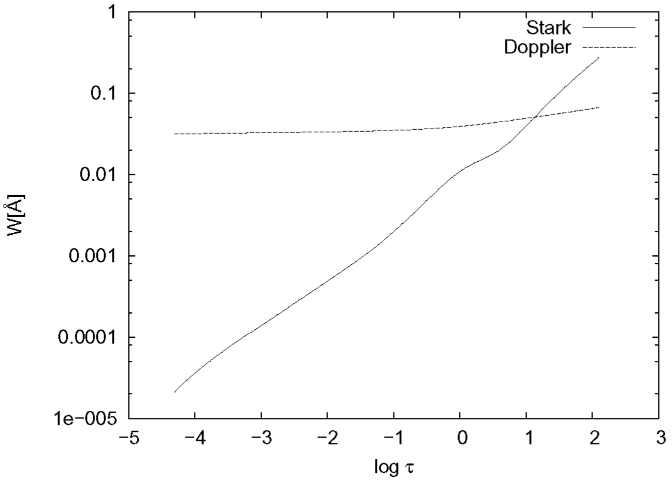

FIGURE 3. Thermal Doppler and Stark widths for Te I 6s $^5S^o$ - 6p ^5P (9903.9 Å) multiplet as functions of optical depth for an A type star (T_{eff} = 10000 K, log g = 4.5).

RESULTS AND DISCUSSION

Atomic energy levels needed for calculations have been taken from Ref. [7]. The oscillator strengths have been calculated within the Coulomb approximation ([8], and using the tables in Ref. [9]). For higher levels, the method of van Regemorter et al. has been used [10].

In Table 1, as a sample of our results, electron-, and proton-impact broadening parameters for three Te I spectral lines for a perturber density of 10^{16}cm^{-3} and temperatures from 2500 up to 50000 K, are shown. The complete results, with a detailed analysis, will be published in [11].

We used the obtained results for the investigation of the influence of Stark broadening in A type star atmospheres in different parts of the spectrum. Consequently, we took one multiplet in the ultraviolet (UV) (2372.7 Å), one in the visible (5125.2 Å), and one in the infrared (IR) (9903.9 Å) part of the spectrum.

Stark widths of 5p^4 ^{3}P - 6s $^5S^o$ (2372.7 Å) multiplet in UV have been compared in Fig. 1 with Doppler widths for a model (T_{eff}=10000 K, log g= 4.5) of A type star atmosphere [12]. Our results are presented as a function of Rosseland optical depth - log τ. The mentioned model for the stellar atmosphere has been used for two other spectral lines, for Te I 6s $^5S^o$ - 7p ^5P (5125.2 Å) multiplet in optical part of the spectrum, and for Te I 6s $^5S^o$ - 6p ^5P (9903.9 Å) multiplet in the IR (see Fig. 2. and 3.).

One can see that for the investigated case, the influence of Stark broadening mechanism is more pronounced in the optical and infrared part of the spectrum than in UV. We can see in Figs. 2 and 3 that for considered optical and IR Te I lines, exist layers in the stellar atmosphere where Stark broadening is dominant or equal to thermal Doppler broadening. For example, Stark width is larger than Doppler one for log $\tau > 0.8$ for the

5125.2 Åline. One should take into account however, that Stark broadened line profile is Lorentzian and Doppler broadened Gaussian, so that even when Stark width is smaller than Doppler one, Stark broadening might be important in the line wings.

One can conclude that, for the considered atmosphere model, Stark broadening effect should be taken into account for neutral tellurium lines, in abundance determination and other investigations of stellar plasmas.

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Influence of Collisions with Charged Particles on Solar Type Star Spectra; Investigations on Belgrade Astronomical Observatory

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Abstract. The significance of Stark broadening for Solar and stellar plasma research is discussed. Since the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level, the Stark broadening contribution may become significant for Rydberg atoms and ions where the optical electron is weakly bound to the core. Consequently, e.g. high member Balmer series lines may be used for Solar plasma diagnostic. The importance of Stark broadening for sub photospheric layers modelling is discussed also. The methods and results developed and obtained on Belgrade Astronomical Observatory and in Serbia are principally discussed .

Keywords: Stark broadening - Solar Rydberg lines - subphotospheric layers - line profiles.
PACS: 32.70.Jz; 95.30.Ky; 97.10Ex

INTRODUCTION

Development of space astronomy and computers stimulates especially the need for a large amount of atomic and spectroscopic data. Particularly large number of data is needed for example for opacity calculations and stellar modelling. For example, PHOENIX (see [1] and references therein) computer code for the stellar modelling includes a database containing data for more than hundred millions atomic/ionic and molecular transitions. The dramatic increase of accuracy and resolution is well illustrated in Fig. 1 where the χ Lupi UV spectrum obtained by IUE (International Ultraviolet Explorer) and GHRS (Goddard High Resolution Spectrograph on Hubble Space Telescope) are compared.

We will discuss here the astrophysical significance of Stark broadening data particularly for Solar and stellar plasma research and the work on this field on Belgrade Astronomical Observatory and Serbia.

ASTROPHYSICAL PLASMA CONDITIONS AND STARK BROADENING

Plasma conditions in astrophysical plasmas are much more various than in laboratory plasma sources. Consequently, broadening due to interaction between emitter and charged particles (Stark broadening) is of interest in astrophysics not only in usual but also in extreme conditions which cannot be obtained in laboratory, like in the interstellar molecular clouds or neutron star atmospheres.

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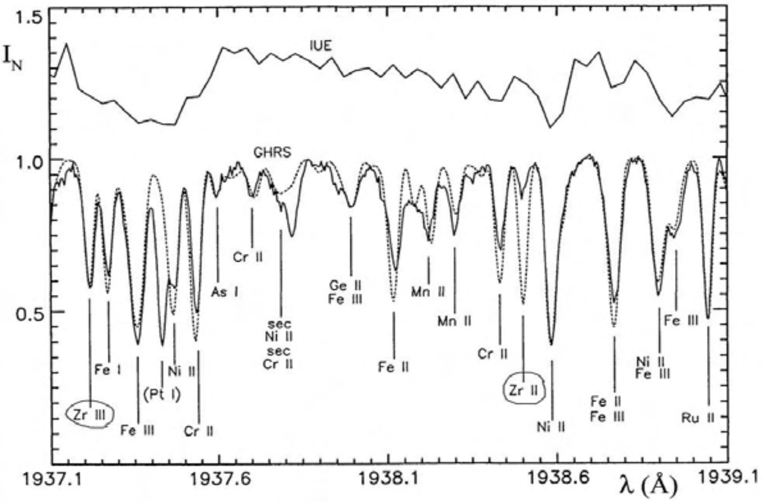

FIGURE 1. The UV spectrum of χ Lupi obtained with GHRS and with IUE satellite [2]. The full line at GHRS spectrum is observed and the dotted synthesized one

In interstellar molecular clouds, typical electron temperatures are around 30 K or smaller, and typical electron densities are 2-15 cm^{-3}. In such conditions, free electrons may be captured (recombination) by an ion in very distant orbit with principal quantum number (n) values of several hundreds and deexcite in cascade to energy levels $n-1, n-2, \ldots$ radiating in radio domain. Such distant electrons are weakly bounded with the core and may be influenced by very weak electric microfield. Consequently, Stark broadening may be significant (see e.g. [3]).

For $T_{\mathrm{eff}} > 10^4$K, hydrogen, the main constituent of stellar atmospheres is mainly ionized, and among collisional broadening mechanisms for spectral lines, the dominant is the Stark effect. This is the case for white dwarfs and hot stars of O, B and A type. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level [4-6] and consequently, Stark broadening contribution may become significant even in the Solar spectrum [7-9]. For example, high member Balmer series lines may be used as a powerful diagnostic tool in studying stellar atmospheres (see e.g. [10]).

On the other side of extreme conditions where Stark broadening is important are neutron stars. The densities of matter and electron concentrations and temperatures in atmospheres of such objects are orders of magnitude larger than in atmospheres of white dwarfs, and are typical for stellar interiors. Surface temperatures for the photospheric emission are of the order of 10^6 - 10^7 K and electron densities of the order of 10^{24} cm^{-3} [11], [12].

LINE SHAPES AND STELLAR PLASMA RESEARCH

Line shapes enter in the models of radiative envelopes by the estimation of the quantities such as absorption coefficient (κ_ν), Rosseland optical depth (τ_{Ross}) and the total opacity cross-section per atom σ_ν(op). Let us take the direction of gravity as z-direction, dealing with a stellar atmosphere. If the atmosphere is in macroscopic mechanical equilibrium and with ρ is denoted gas density, the optical depth is

$$\tau_\nu = \int_z^\infty \kappa_\nu \rho dz, \tag{1}$$

$$\kappa_\nu = N(A,i)\phi_\nu \frac{\pi e^2}{mc} f_{ij}, \tag{2}$$

where κ_ν is the absorption coefficient at a frequency ν, $N(A,i)$ is the volumic density of radiators in the state i, f_{ij} is the absorption oscillator strength, m is the electron mass and ϕ_ν spectral line profile. Let us introduce an independent variable, a mean optical depth

$$\tau_{Ross} = \int_z^\infty \kappa_{Ross} \rho dz. \tag{3}$$

For the Rosseland mean optical depth τ_{Ross}, κ_{Ross} is defined as

$$\frac{1}{\kappa_{\text{Ross}}} \int_0^\infty \frac{dB_\nu}{dT} d\nu = \int_0^\infty \frac{1}{\kappa_\nu} \frac{dB_\nu}{dT} d\nu, \tag{4}$$

where

$$B_\nu(T) = \frac{2h\nu^3}{c^2}(e^{h\nu/kT} - 1)^{-1}. \tag{5}$$

Stark broadening parameters are needed as well for the determination of the chemical composition of stellar atmospheres i.e. for stellar elemental abundances determination. The method which uses synthetic and observed spectra and adjustment of atmospheric model parameters to obtain the best agreement is well developed and applied to many stars.

CALCULATION OF NEEDED STARK BROADENING PARAMETERS AND THE MODIFIED SEMIEMPIRICAL METHOD

When we need to calculate Stark broadening parameters of spectral lines, needed for solar or stellar plasma analysis one of possibilities is to use the modified semiempirical (MSE) approach [13-16], developed in Serbia for the calculation of Stark widths and shifts for non-hydrogenic ion spectral lines. From its formulation in 1980, the considered method has been applied successfully many times for different problems in astrophysics and physics.

In comparison with the full semiclassical approach [17-19] and the Griem's semiempirical approach [20] who needs practically the same set of atomic data as the more sophisticated semiclassical one, the modified semiempirical approach [13-16] needs a considerably smaller number of such data. In fact, if there are no perturbing levels strongly violating the assumed approximation, for *e.g.* the line width calculations, we need only the energy levels with $\Delta n = 0$ and $\ell_{if} = \ell_{if} \pm 1$, since all perturbing levels with $\Delta n \neq 0$, needed for a full semiclasical investigation or an investigation within the Griem's semiempirical approach [20], are lumped together and approximately estimated. Here, n is the principal and ℓ the orbital angular momentum quantum numbers of the optical electron and with i and f are denoted the initial and final state of the considered transition.

Due to the considerably smaller set of needed atomic data in comparison with the complete semiclassical [17-19] or Griem's semiempirical [20] methods, the MSE method is particularly useful for stellar spectroscopy depending on very extensive list of elements and line transitions with their atomic and line broadening parameters where it is not possible to use sophisticated theoretical approaches in all cases of interest.

The MSE method is also very useful whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important like e.g. for opacity calculations or plasma modelling. Moreover, in the case of more complex atoms or multiply charged ions the lack of the accurate atomic data needed for more sophisticated calculations, makes that the reliability of the semiclassical results decreases. In such cases the MSE method might be very interesting as well.

SIMPLIFIED MSE FORMULA

For the astrophysical purposes, of particular interest might be the simplified semiempirical formula [15] for Stark widths of isolated, singly, and multiply charged ion lines applicable in the cases when the nearest atomic energy level ($j' = i'$ or f') where a dipolly allowed transition can occur from or to initial (i) or final (f) energy level of the considered line, is so far, that the condition $x_{\mathrm{jj'}} = E/|E_{\mathrm{j'}} - E_{\mathrm{j}}| \leq 2$ is satisfied. In such a case full width at half maximum is given by the expression (6):

$$W(\mathring{A}) = 2.2151 \times 10^{-8} \frac{\lambda^2(\mathrm{cm}) N(\mathrm{cm}^{-3})}{T^{1/2}(\mathrm{K})} (0.9 - \frac{1.1}{Z}) \sum_{\mathrm{j=i,f}} (\frac{3n_{\mathrm{j}}^*}{2Z})^2 (n_{\mathrm{j}}^{*2} - \ell_{\mathrm{j}}^2 - \ell - 1). \quad (6)$$

Here, N and T are the electron density and temperature respectively, $E = 3kT/2$ is the energy of perturbing electron, $Z - 1$ is the ionic charge and n the effective principal quantum number. This expression is of interest for abundance calculations, as well as for stellar atmospheres research, since the validity conditions are often satisfied for stellar plasma conditions.

Similarly, in the case of the shift

$$d(\mathring{A}) = 1.1076 \times 10^{-8} \frac{\lambda^2(\mathrm{cm}) N(\mathrm{cm}^{-3})}{T^{1/2}(\mathrm{K})} (0.9 - \frac{1.1}{Z}) \frac{9}{4Z^2} \times \quad (7)$$

$$\times \sum_{\mathrm{j=i,f}} \frac{n_{\mathrm{j}}^{*2}\varepsilon_{\mathrm{j}}}{2\ell_{\mathrm{j}}+1}\{(\ell_{\mathrm{j}}+1)[n_{\mathrm{j}}^{*2}-(\ell_{\mathrm{j}}+1)^2]-\ell_{\mathrm{j}}(n_{\mathrm{j}}^{*2}-\ell_{\mathrm{j}}^2)\}. \tag{8}$$

If all levels $\ell_{\mathrm{i,f}} \pm 1$ exist, an additional summation may be performed in Eq. (16) to obtain

$$d(\mathring{A}) = 1.1076\times 10^{-8}\frac{\lambda^2(\mathrm{cm})N(\mathrm{cm}^{-3})}{T^{1/2}(\mathrm{K})}(0.9-\frac{1.1}{Z})\frac{9}{4Z^2}\sum_{\mathrm{j=i,f}}\frac{n_{\mathrm{j}}^{*2}\varepsilon_{\mathrm{j}}}{2\ell_{\mathrm{j}}+1}(n_{\mathrm{j}}^{*2}-3\ell_{\mathrm{j}}^2-3\ell_{\mathrm{j}}-1), \tag{9}$$

where $\varepsilon = +1$ for $j = i$ and -1 for $j = f$.

SOME OTHER METHODS FOR STARK BROADENING PARAMETER DETERMINATION DEVELOPED OR USED IN BELGRADE

In a lot of cases such as e.g. complex spectra, heavy elements or transitions between highly excited energy levels, the more sophisticated quantum mechanical approach is very difficult or even practically impossible to use and, in such cases, the semiclassical approach remains the most efficient method for Stark broadening calculations.

In order to complete as much as possible Stark broadening data needed for astrophysical and laboratory plasma research and stellar opacities calculations we are making a continuous effort to provide Stark broadening data for a large set of atoms and ions. In a series of papers we have performed large scale calculations of Stark broadening parameters for a number of spectral lines of various emitters, within the semiclassical - perturbation formalism [17,18], for transitions when a sufficiently complete set of reliable atomic data exists and a good accuracy of obtained results is expected. Our semiclassical Stark broadening parameters, were used for different astrophysical problems, as e.g. for comparison with theoretical results obtained within the Stark broadening theory of solar Rydberg lines in the far infrared spectrum [21]. Also, our semiclassical results for lithium [22] have been used for a study of the non-LTE formation of Li I lines in cool stars [23] and our data for Mg I [24] for a non-LTE analysis of Mg I in the solar atmosphere [25].

When reliable data do not exist, the knowledge on regularities and systematic trends of line broadening parameters can be used for quick acquisition of new data especially when high accuracy of each particular value is not needed. This method to quickly estimate Stark broadening parameters, is mainly elaborated in Serbia (see e.g. [26-33]). The aim of such studies is to find out how regularities and systematic trends can be used to predict line widths and to critically evaluate experimental data. With the suitable use of the knowledge of regularities and systematic trends, we might use the existing experimental and theoretical values for the interpolation of new data needed in stellar spectroscopy. One must take into account however, that the validity of systematic trends and line broadening data is limited to the plasma conditions for which they are derived and extrapolations are of low accuracy.

Stark broadening research is a developed research field in Serbia, which has a critical mass of scientists and due to its often interdisciplinary significance provides a good basis for scientific collaboration. In Refs. [34-38] spectral line shapes investigations in Yugoslavia and Serbia within 1962 - 2000 period has been reviewed. It is shown that during this period 1427 (1222 by Serbian authors) bibliographic items have been published by 179 Yugoslav authors (152 from Serbia, 26 from Croatia and 1 living in France). Majority of these articles concern Stark broadening. These publications, containing also citation analysis, offer additionally a possibility to analyze the results of investigations and their applications in order to show possibilities for development of collaboration.

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Stark Broadening of Spectral Lines for Solar and Stellar Plasma Research

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Abstract. Here we give a review of problems in solar and stellar plasma investigations where Stark broadening data are of interest, as well as of some of Belgrade school theoretical results in this research field.

1. Significance of Stark Broadening Data in Astrophysics

Broadening due to interaction between an emitter and charged particles (Stark broadening) is of interest for solar and stellar plasma research, but also even for extreme conditions in interstellar molecular clouds or neutron star atmospheres investigations. It is first of all interesting for hotter stars like A-type stars, PG1195-type stars and white dwarfs, where the hydrogen, the main constituent of stellar atmospheres, is mainly ionized. Among the collisional broadening mechanisms for spectral lines, the dominant is the Stark effect. However, even in cooler star atmospheres, e.g. Sun, Stark broadening may be important for studying of subphotospheric layers.

For the determination of chemical abundances of elements from equivalent widths of absorption lines, for opacity calculations and stellar plasma modelling, many complete sets of Stark broadening data, as many as the number of spectral lines for different emitters are needed, since we do not know *a priori* the chemical composition of a star.

The interest for a very extensive list of line broadening data is additionally stimulated by the development of space born spectroscopy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, with increasing resolution, stimulating the spectral−line−shape research.

2. Stark Broadening and Solar Plasma

For Solar plasma investigations, diagnostic and modelling, Stark broadening may be of interest in several cases.

First of all, profiles of Solar H lines, especially higher members of Balmer series may be affected by Stark broadening, particularly in active regions, where electron density is higher than in surrounding areas. For example, investigating the white light flare occured on 27 Oct. 1991 in an active region, Lee & Yun (1995) have found that the lower Balmer lines observed during the flare activity are broadened by Stark effect. Also Li et al. (1995) have found that solar prominence H lines with shallow self reversal were influenced with this broadening mechanism. The evidence for Stark broadening in the Balmer lines have found by Johns-Krull et al. (1997) in time-resolved high-resolution optical spectra of a relatively large solar flare event which they observed on 1993 March 6.

One should take into account also that the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level (see Dimitrijević & Sahal-Bréchot 1985 and references therein) and consequently, Stark broadening contribution may become significant for highly excited lines in the Solar spectrum (see Vince et al. 1985ab). For example, high member Balmer series lines may be used as a powerful diagnostic tool in studying stellar atmospheres. In Feldman & Doschek (1977), profiles of Balmer series members with the principal quantum number n between 16 and 32 (strongly influenced by Stark effect) have been used to determine the electron density and the temperature over an active Solar region. Also Chang & Deming (1997) have analyzed infrared (8 to 20 microns) spectra of a quiescent and an active prominence and have identified a higher excitation hydrogen line and two helium recombination lines and determined the electron density using Stark broadening data. Stark broadening theory of solar Rydberg lines in the far infrared spectrum is given in van Regemorter & Hoang-Binh (1993). The theory of electron and proton broadening of solar lines is reviewed in Chang & Deming (1998) and a non-LTE analysis of Mg I in the solar atmosphere is performed in Zhao et al. (1998).

Also, for the estimation of radiative transfer through the solar subphotospheric layers Stark broadening data are needed since with the increase of electron density, the role of this line broadening mechanism increases.

3. Stark Broadening and Stellar Plasma Research

Stark broadening is the most significant pressure broadening mechanism for A and B stars (see Fig. 5 for 38 Nd II lines in Popović et al. 2001). This effect should be taken into account in investigations, analysis, and modelling of their atmospheres. In Popović et al. (1999, 2001) and Dimitrijević et al. (2003) we have shown that Stark broadening may change spectral line equivalent widths by 10-45%; hence neglecting this mechanism may introduce significant errors in abundance determinations. Stark data become extremely important after discovering abundance gradients in the atmospheres of magnetic, chemically peculiar (Ap) stars. High resolution spectra allow us to perform stratification analysis using line profiles, and strong lines with developed wings provide us with the most accurate information about distribution of the element through the stellar atmosphere (see Dimitrijević et al. 2003 for Si and Dimitrijević et al. 2005 for Cr).

The influence of Stark broadening increases with temperature and with electron density, so that for O star atmospheres, in spite of high temperature, Stark broadening is much less important than for A stars due to lower electron density. However, among the hottest stars are PG1159 stars, hot hydrogen deficient pre-white dwarfs, with sufficient electron density and with effective temperatures of around 100 000 - 140 000 K, where of course Stark broadening is very important. The spectra, which are strongly influenced by Stark broadening, are dominated by He II, C IV, O VI and N V lines.

White dwarfs have effective temperatures between around 10 000 and 30 000 K so that Stark broadening is also of interest for their spectra investigation and plasma research, analysis and modelling. Also, electron concentrations and temperatures in atmospheres of neutron stars are typical for stellar interiors. In Madej (1989), the final opacity profile of He-like iron resonant lines is described by a Voigt profile, with a total damping parameter equal to the sum of natural and Stark (electron - impact) broadening.

4. Stark Broadening Investigations on Belgrade Astronomical Observatory

In order to improve the quality and quantity of available Stark broadening data needed for astrophysical and laboratory plasma research and stellar opacities calculations, we are making a continuous effort to provide Stark broadening data for a large set of atoms and ions. In a series of papers we have performed large scale calculations of Stark broadening parameters for a number of spectral lines of various emitters (see e.g. Dimitrijević 2003 and references therein). The used semiclassical - perturbation formalism and all innovations and optimizations of the computer code have been discussed several times (Dimitrijević & Sahal-Bréchot 1996).

Our semiclassical Stark broadening parameters, were used for different astrophysical problems (see Dimitrijević 2003 and references therein). For example in Solar plasma research, they were used for comparison with theoretical results obtained within the Stark broadening theory of solar Rydberg lines in the far infrared spectrum (van Regemorter & Hoang-Binh 1993), and for a non-LTE analysis of Mg I in the solar atmosphere (Zhao et al. 1998).

We also developed the MSE Modified Semi-Empirical method (see Dimitrijević & Popović (2001) and references therein), which is useful whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important, e.g. for opacity calculations or plasma modeling. Moreover, in the case of more complex atoms or multiply charged ions, lack of accurate atomic data which are needed for more sophysticated calculations, makes that the reliability of the semiclassical results decreases. In such cases the MSE method might be very interesting as well.

Belgrade group (Milan S. Dimitrijević, Luka Č. Popović, Vladimir Kršljanin, Dragana Tankosić, Nenad Milovanović, Zoran Simić, Miodrag Dačić, Predrag Jovanović) used the modified semiempirical method to obtain the Stark width and in some cases shift data for a large number of spectral lines for the different atom and ion species (see Dimitrijević & Popović (2001) and references therein).

In order to make the application and usage of our Stark broadening data obtained within the semiclassical and modified semiempirical approaches more easier, we are organizing them now in the database BELDATA on Belgrade Observatory and MOLAT at Paris Observatory (see for details Dimitrijević & Popović 2006).

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A New Approach of the GR Model

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1. Introduction

In the spectra of Hot Emission Stars (Oe and Be stars) we observe peculiar line profiles. In order to explain this peculiarity, we propose the DACs (Bates & Halliwell 1986) and SACs phenomenon (Danezis et al. 2005). We study these phenomena using the GR model, which presumes that the regions, where the spectral lines are created, consist of a number of independent and successive absorbing or emitting density regions of matter (Danezis et al. 2007). Here we are testing a new approach of GR model, which assumes independent but not successive density regions. Then, we compare the results of this method with the classical GR model that assumes successive regions.

2. Results - Conclusions

We study the density regions that produce the C IV ($\lambda\lambda$ 1548.155, 1550.774 Å) resonance lines in the spectra of the Oe stars HD 57061, HD 93521, HD 47129, HD 24911 and HD 49798, as well as the Fe II (λ 2585.876 Å) spectral line in the spectra of the Be stars HD 30386, HD 42335, HD 53367, HD 45910 and HD 200120. In Figs. 1 and 2 we present the results of our study. In all cases, comparing the results, the mean values of all the kinematic parameters do not depend on the applied method. This is what we theoretically expected. However, the method of the independent but not successive layers of matter gives higher values of the absorbed energy than the method of the independent and successive layers of matter.

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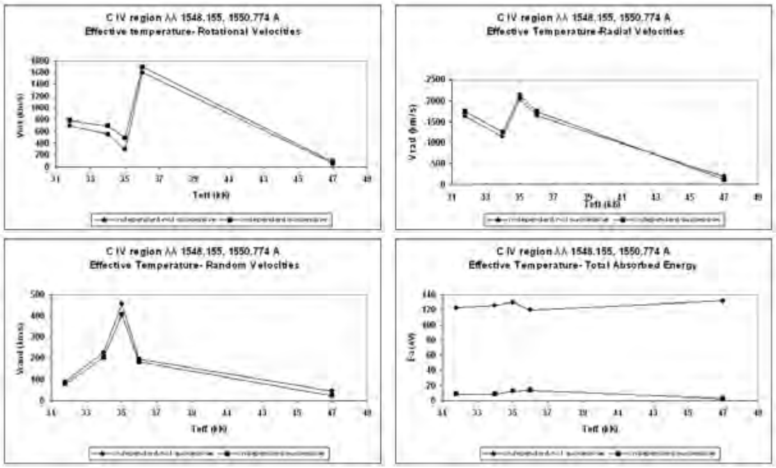

Figure 1.: Variation of the values of the rotational velocities (up-left), radial velocities (up-right), random velocities of the ions (down-left) and the total absorbed energy (down-right) as a function of the effective temperature of the studied Oe stars in the C IV ($\lambda\lambda$ 1548.155, 1550.774 Å) regions. The circles correspond to the case of independent but not successive layers of matter, while the squares correspond to the case of the independent and successive layers of matter.

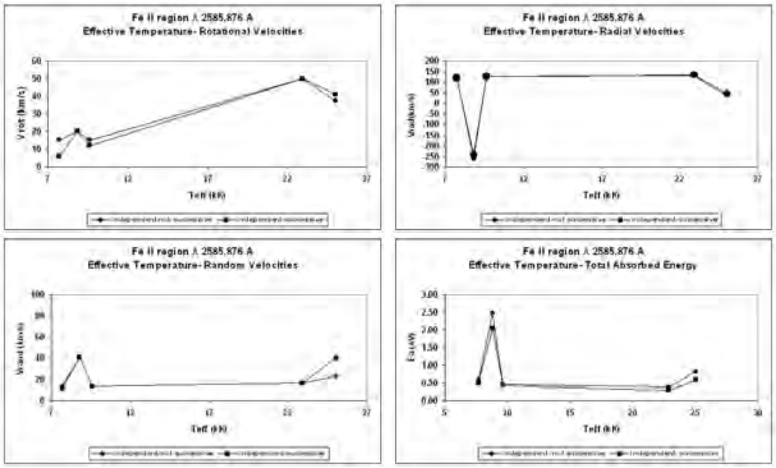

Figure 2.: Variation of the values of the rotational velocities (up-left), radial velocities (up-right), random velocities of the ions (down-left) and the total absorbed energy (down-right) as a function of the effective temperature of the studied Be stars in the Fe II (λ 2585.876 Å) regions. The circles correspond to the case of independent but not successive layers of matter, while the squares correspond to the case of the independent and successive layers of matter.

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Investigating DACs/SACs Phenomena in Hot Emission Stars and Quasars

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1. Introduction

The spectra of hot emission stars and AGNs present peculiar profiles that result from dynamical processes such as accretion and/or ejection of matter from these objects. In the UV spectra of hot emission stars and AGNs the absorption lines have DACs or SACs that are shifted to the blue.

In the case of hot emission stars, DACs or SACs arise from spherical density regions around the star or from density regions far away from the star that present spherical (or apparent spherical) symmetry around their own center (Bates & Halliwell 1986; Danezis et al. 2005, 2006a). Similar phenomena can be detected in the spectra of AGNs. Wind (jets, ejection of matter etc.), BLR (Broad Line Regions) and NLR (Narrow Line Regions) are, probably, the density regions that construct these profiles of the spectral lines (Danezis et al. 2006a).

In order to study the observed peculiar profiles in the spectra of hot emission stars and AGNs, we use the GR model (Danezis et al. 2007). With this model we can reproduce the complex profiles of the spectral lines and we can calculate some important parameters of the density regions that construct the DACs-SACs, such as the apparent rotational and radial velocities of the absorbing or emitting density layers, the Gaussian typical deviation of the ions random motions and the optical depth in the center of the absorption or emission components (direct calculations). Indirectly we can calculate the random velocities of the ions, the FWHM, the absorbed or emitted energy and the column density.

In this paper we indicate that DACs and SACs phenomena, can explain the spectral lines peculiarity in hot emission stars and AGNs (Danezis et al. 2006b, 2008). We also try to connect the physical properties of absorption regions around stars and quasars.

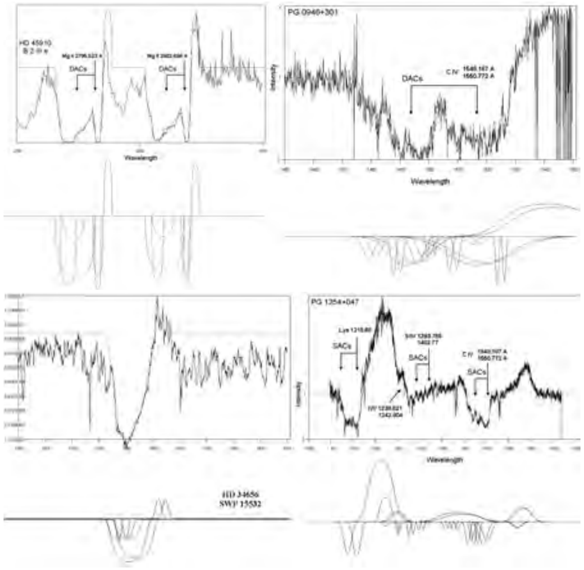

Figure 1.: Up: DACs in the spectra of Hot Emission Stars (left) and AGNs (right). Down: SACs in the spectra of Hot Emission Stars (left) and AGNs (right). Below the GR model fit one can see the analysis of the observed profile to its DACs or SACs.

2. Results and Discussion

Here we applied the GR model (Danezis et al. 2005, 2007) in order to fit some stellar and quasar's absorption lines (see Fig. 1). In both cases we can find blue-shifted components, which are indicating an outflow (wind) in both objects. However, there are differences in the velocities, i.e. naturally the outflow velocities in quasars are higher ($\sim$ several 1000 km/s). But, the line profiles (as e.g. P-Cygni profile) in both objects are similar, indicating that natural phenomena are similar, but with different physical properties.

As we can see in Fig. 1 (up-right) we can detect the DACs phenomenon in the spectra of some AGNs constructing complex profiles. The presence of DACs phenomenon in the spectra of some AGNs leads us to search also for SACs in these spectra. In Fig. 1 (down-right), using the GR model, we can see that the complex structure of many AGNs' spectral lines can be explained with SACs phenomenon.

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Ways of creation of DACs and SACs in the spectra of PG 0946+301 and PG 1254+047

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1. Introduction

Assuming that the Broad Line Regions - BLR (originated in a disk wind) are composed of a number of successive independent absorbing density layers, which have the random, rotational and radial velocity, we used the GR model (Danezis et al. 2007) in order to fit broad spectral lines. By fitting the observed absorption lines with the model we take the basic parameters of BLRs (random, rotation and radial velocities and column density). This model supposes that the density regions of matter that construct the BLRs are independent and successive.

Here we investigate the physical properties of Broad Absorption Line Regions (BALRs) of the BALQSOs PG 0946+301 (Z=1.216) and PG 1254+047 (Z=1.024) by applying the GR model on their spectra. Specifically, we study the C IV $\lambda\lambda$ 1548.187, 1550.772 Å, Si IV $\lambda\lambda$ 1393.755, 1402.77 Å, N V $\lambda\lambda$ 1238.821, 1242.804 Å UV resonance lines and the Lya λ 1215.68 Å spectral line.

2. The method

In order to study the BALs and the BELs we use the GR model (Danezis et al. 2007), which can be used successfully, for both hot emission stars and AGNs. By solving the radiation transfer equations through a complex structure of successive and independent layers of matter, we conclude to the function

$$I_\lambda = \left[I_{\lambda 0} \prod_i \exp\left\{-L_i \xi_i\right\} + \sum_j S_{\lambda ej}\left(1 - \exp\left\{-L_{ej}\xi_{ej}\right\}\right)\right] \prod_g \exp\left\{-L_g \xi_g\right\}$$

for the line profile, which is able to give the best fit for the main spectral line and its Satellite Components at the same time.

In the GR line function, in the case of a number of independent and successive absorbing or emitting density layers of matter the final profile that is produced by a group of absorption lines is given by the product of the line functions of each component.

An idea of our scientific group is to examine the form of GR line function if the density regions of matter that produce the satellite absorption or emission components are independent but not successive. In this case the GR line Function has the fowling form $I_\lambda = I_{\lambda 0}\sum\limits_i \exp\left\{-L_i\xi_i\right\} + \sum\limits_j S_{\lambda ej}\left(1 - \exp\left\{-L_{ej}\xi_{ej}\right\}\right)$

3. Results - Conclusions

We found that the peculiar profiles of the studies lines are created by a number of Satellite Absorption Components (SACs). An exceptional phenomenon is that the C IV doublet of PG 0946+301 is one of the very few lines presenting clearly Discrete Absorption Components (DACs), in the case of quasars. Finally, we calculated some kinematical parameters such as the apparent radial and rotational velocities of the regions that create the studied lines, the random velocities of the ions and the total absorbed energy of the same regions.

In both cases of PG 0946+301 and PG 1254+047 we observe that the mean values of all the kinematic parameters and the absorbed energy do not change depending on the applied method (successive and not successive layers of matter). In Fig. 1 we present, as an example, the values of the rotational and radial velocities of the regions which create the Lya, Si IV, C IV and N V spectral lines of PG 0946+301 and the random velocities of the ions and the values of the total absorbed energy of the same regions, calculated in the cases that the independent density regions of matter producing the absorption or emission satellite components are successive (black circles) or not (white circles).

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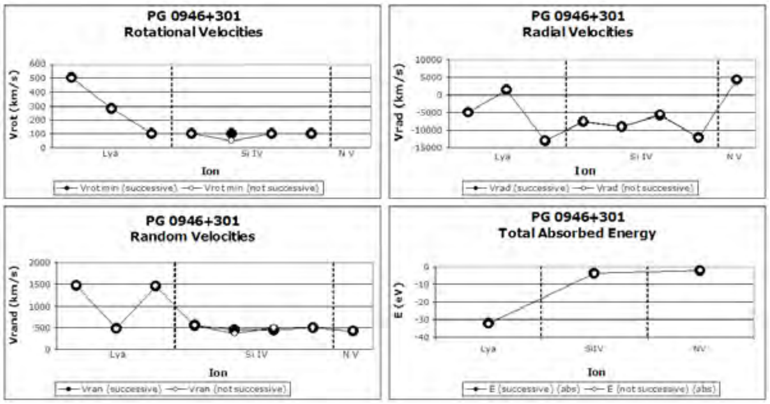

Figure 1.: Rotational Velocities (up-left), radial velocities (up-right), random velocities (down-left) and total absorbed energy (down-right) taken from the analysis of the Lya, Si IV, C IV and N V spectral lines in the case of successive (black circles) or not successive (white circles) density regions. One can see that there is almost no difference between the two cases.

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ON THE STARK BROADENING OF Mg I SPECTRAL LINES IMPORTANT FOR SOLAR AND STELLAR SPECTRA INVESTIGATIONS

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1. INTRODUCTION

Stark broadening parameters of neutral magnesium spectral lines are of interest for the investigation of Solar plasma, since such lines are observed in the Solar spectrum, and particulary in its infrared part, the influence of charged particles producing Stark broadening effect is not negligible. The infrared lines of Mg I have been observed in the Solar spectrum at Kitt Peak and during the Atmos experiment on Spacelab. Due to the suitability of these lines for the solar atmosphere investigations (see e.g. Van Regemorter & Hoang-Binh 1993) and to the fact that with the increase of the principal quantum number increases the importance of Stark broadening as well, the corresponding Stark widths and shifts are of importance for the structure of the Solar atmosphere research and solar plasma diagnostic. Stark broadening data for Mg I lines are also of interest for laboratory plasma research and have been investigated experimentally and theoretically several times.

By using the semiclassical-perturbation formalism we have calculated electron-, proton-, Mg II-, Si II-, and Fe II-impact line widths and shifts for 267 Mg I multiplets , in order to provide the needed Stark broadening parameters for all important perturbers for investigation and modelling of Solar plasma. Moreover, for the laboratory plasma research, Ar II-impact broadening parameters have been calculated as well. A summary of the formalism is given in Dimitrijević *et al.* (1991). Obtained results will be published elsewhere (Dimitrijević and Sahal-Bréchot, 1996) and here they will be only discussed.

2. RESULTS AND DISCUSSION

In Table 1 our results (denoted as DSB) for Stark full widths for Mg I $5g^1G$ - $6h^1H$ and $6g^1G$ - $7h^1H$ transitions have been compared with results of Regemorter and Hoang Binh (1993) (denoted as RHB), with calculation within the Griem's (1968) semiempirical approach of Carlsson et al. (1992) (denoted as GCRS) and with calculations of Chang and Schoenfeld (1991) by using the Lindholm (1941) adiabatic theory (LCS). One can see that our calculations are in good agreement with the width calculations of Regemorter and Hoang Binh (1993) while for shifts the differences due to the neglection of perturbing levels with the different principal quantum number exist. The adiabatic theory of Lindholm (1941) used by Chang and Schoenfeld (1991), in spite of its inadequacy, is in relatively good agreement with experimental widths but largely overestimates the shift, while the Griem's (1968) semiempirical approach, not appropriated for transitions between nearly degenerate states (GCRS), is in agreement with our results for Mg I $5g^1G$ - $6h^1H$ transition but gives more than two times smaller result for $6g^1G$ - $7h^1H$ transition.

Table 1. Comparison of electron-impact width (W - FWHM) and shift (d) values calculated according to various approaches, for Mg I $5g^1G$ - $6h^1H$ and $6g^1G$ - $7h^1H$ transitions at an electron density of 10^{12} cm^{-3} for T = 5000 K. The notation is: DSB - present calculations; RHB - Regemorter and Hoang Binh (1993); GCRS - calculated by Carlson, Rutten and Schukina (1992) by using the Griem's (1968) semiempirical formula with an effective Gaunt factor g = 0.5; LCS - calculated by Chang and Schoenfeld (1991) by using the Lindholm (1941) adiabatic theory.

Transition	DSB	RHB	GCRS	LCS
5g - 6h				
W[Å]	0.18	0.16	0.21	0.25
d[Å]	0.0034	0.013	-	0.22
6g - 7h				
W[Å]	2.48	2.67	1.07	2.73
d[Å]	-0.0128	0.052	-	2.36

We hope that the comprehensive set of Stark broadening parameters of Mg I lines will enable the better use of Mg I spectral lines for solar plasma research.

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LINE BROADENING DATA: STARK BROADENING OF Ca II Sc III AND Ti IV LINES

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ABSTRACT Electron- and proton-impact line widths and shifts for important Ca II, Sc III and Ti IV lines, have been calculated using the semiclassical-perturbation formalism. The obtained results were used to investigate the behaviour of Stark broadening parameters within the K I isoelectronic sequence.

INTRODUCTION

Stark broadening of spectral lines has been taking a new interest in astrophysics (Seaton, 1987), owing to the recent development of researches on the physics of stellar interiors: in subphotospheric layers, the modellisation of energy transport needs the knowledge of radiative opacities and thus, certain atomic processes must be known with accuracy.In order to provide a method for quick interpolation of new data along an isoelectronic sequence it is of interest to investigate if a sufficiently regular behaviour of Stark broadening parameters along such a sequence exists. Consequently, one of aims of this paper is to provide Stark broadening data for a number of transitions within several members of an isoelectronic sequence.

The present paper concerns Ca II, Sc III and Ti IV lines from the kalium isoelectronic sequence. Beyond the interest for the stellar atmospheres investigation and the modellisation of stellar interiors, the knowledge of Ca II, Sc III and Ti broadening parameters is important for a number of problems in astrophysics and plasma physics. Particularly is important Ca II which is among the most abundant elements in stellar plasma after hydrogen and helium.

RESULTS AND DISCUSSION

In order to provide reliable data for the mentioned lines broadened by collisions with all important charged perturbers in stellar plasmas, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 28 Ca II (Dimitrijević et al, 1992ab), 10 Sc III and 10 Ti IV

TABLE I This table shows electron- and proton-impact broadening parameters for Ca II, Sc III and Ti IV lines, for perturber density of 10^{17} cm^{-3} as a function of temperature. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By deviding c with electron-impact WIDTH we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used. The asterisk identifies cases for which the collision volume multiplied by the perturber density (the condition for validity of the impact approximation) lies between 0.1 and 0.5.

PERTURBER DENSITY = 0.1D+18(cm-3)

PERTURBERS ARE		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
CA II 3D-4P	5000.	1.34	0.595E-01	0.397E-01	-0.642E-02
8581.1 A	10000.	1.05	0.308E-01	0.666E-01	-0.129E-01
C= 0.86E+21	20000.	0.856	0.228E-01	0.927E-01	-0.209E-01
	30000.	0.776	0.913E-02	0.101	-0.255E-01
	50000.	0.707	0.736E-02	0.112	-0.309E-01
	100000.	0.643	0.792E-02	0.125	-0.374E-01
CA II 3D-5P	5000.	0.303	-0.363E-01	0.238E-01	-0.737E-02
2132.3 A	10000.	0.241	-0.220E-01	0.308E-01	-0.115E-01
C= 0.17E+20	20000.	0.207	-0.224E-01	0.359E-01	-0.152E-01
	30000.	0.196	-0.182E-01	0.391E-01	-0.170E-01
	50000.	0.189	-0.146E-01	0.410E-01	-0.198E-01
	100000.	0.183	-0.132E-01	0.431E-01	-0.225E-01
CA II 3D-6P	5000.	0.413	-0.129		
1644.1 A	10000.	0.358	-0.988E-01		
C= 0.48E+19	20000.	0.333	-0.783E-01	*0.730E-01	-0.374E-01
	30000.	0.328	-0.634E-01	*0.762E-01	-0.415E-01
	50000.	0.332	-0.552E-01	*0.806E-01	-0.477E-01
	100000.	0.334	-0.436E-01	*0.885E-01	-0.558E-01
SCIII 3D-4P	20000.	0.278E-01	0.836E-03	0.105E-02	0.153E-03
1605.1 A	50000.	0.183E-01	0.894E-03	0.184E-02	0.331E-03
C= 0.95E+20	100000.	0.140E-01	0.785E-03	0.227E-02	0.477E-03
	200000.	0.113E-01	0.869E-03	0.257E-02	0.613E-03

TIIV 3D-4P	20000.	0.596E-02	0.758E-04	0.787E-04	0.128E-04
777.8 A	50000.	0.384E-02	0.913E-04	0.198E-03	0.326E-04
C= 0.29E+20	100000.	0.281E-02	0.912E-04	0.295E-03	0.563E-04
	200000.	0.215E-02	0.109E-03	0.373E-03	0.816E-04
TIIV 3D-5P	20000.	0.473E-02	0.553E-04	0.236E-03	0.127E-04
433.7 A	50000.	0.335E-02	0.891E-04	0.394E-03	0.298E-04
C= 0.35E+19	100000.	0.270E-02	0.891E-04	0.467E-03	0.457E-04
	200000.	0.227E-02	0.984E-04	0.525E-03	0.627E-04

multiplets (Dimitrijević and Sahal-Bréchot, 1992c), using the semiclassical-perturbation formalism (Sahal-Bréchot, 1969ab). This is a part of an effort to provide reliable Stark broadening data for stellar plasma research (see the review on up to now performed calculations for He I, Na I, K I, F I, Be II, Mg II, Ca II, Sr II, Ba II, Si II, Ar II, Ga II, Ga III and several lines of other light elements, in Dimitrijević and Sahal-Bréchot, 1991).

As an example, in Table I are presented results for some important Ca II, Sc III and Ti IV lines. The obtained results were used also to investigate the behaviour of Stark broadening parameters within the isoelectronic sequence in order to examine the use of such behaviour for the interpolation of new data of interest for the stellar plasma investigations. Our analysis shows that a regular behaviour exist but the mutual relation of the corresponding Stark broadening parameters depends on temperature. Additional experimental and theoretical work for the investigated case is needed as well as the extension to the other members of K isoelectronic sequence.

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ON STARK BROADENING OF HEAVY ELEMENT LINES IN A–TYPE STAR SPECTRA: Bi II LINES

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ABSTRACT We report here results of Bi II spectral lines Stark broadening research within the modified semiempirical approach. The strong absorption Bi II lines observed in Hg – Mn star atmospheres have been investigated as well as the influence of the departure from LS – coupling and the correct knowledge of ionization potential. The obtained results have been compared with other estimations and with experimental results.

INTRODUCTION

Stark broadening data are of the great importance for astrophysical and laboratory plasma spectroscopy. For evaluation and modelling of stellar atmospheric physical properties and abundace determinations, Stark broadening data for a large number of transitions in many atoms are needed.

Seven strong absorption lines of ionized bismuth have been found in the Hg – Mn star HR 7775 in high – resolution spectra obtained with IUE (Jacobs and Dworetsky, 1982). Performed analysis shows existence of the overabundance of Bi of 10^6 while Jacobs and Dworetsky (1982) have not detected Bi II in the spectra of several other Hg – Mn stars. Since the plasma conditions in HR 7775 star atmosphere are $T_{eff} = 11000$ K, $\log g = 4.0$ (Jacobs and Dworetsky, 1982), it is of interest to provide the corresponding Stark broadening parameters which might be of significance for abundance investigation, determination of astrophysical gf values and other stellar plasma research. Besides of an astrophysical importance, Stark broadening of Bi II lines is interesting and for labaratory plasma research and was investigated experimentally by Miller and Bengston (1980) and Purić et *al.*, (1985). Moreover the case of Bi II lines is interesting from the theoretical point of view since this is an example of depature from LS - coupling which gives the opportuity to study influence of such effect on Stark broadening parametars.

THEORY

According to modified semiempirical approach, electron impact width (HWHM) of an ion line is given by the experssion (Dimitrijević and Konjević, 1980):

$$w = N\frac{2h^2}{3m^2}(\frac{2m}{3\pi kT})^{1/2} \cdot \{\vec{R}^2_{l_i,l_{i+1}}\widetilde{g}(x_{l_i,l_{i+1}}) + \vec{R}^2_{l_i,l_{i-1}}\widetilde{g}(x_{l_i,l_{i-1}}) + \vec{R}^2_{l_f,l_{f+1}}\widetilde{g}(x_{l_f,l_{f+1}}) +$$

$$\vec{R}^2_{l_f,l_{f-1}}\widetilde{g}(x_{l_f,l_{f-1}}) + \sum_{i'}(\vec{R}^2_{ii'})_{\Delta n\neq 0}g(x_{n_i}) + \sum_{f'}(\vec{R}^2_{ff'})_{\Delta n\neq 0}g(x_{n_f})\} \quad (1)$$

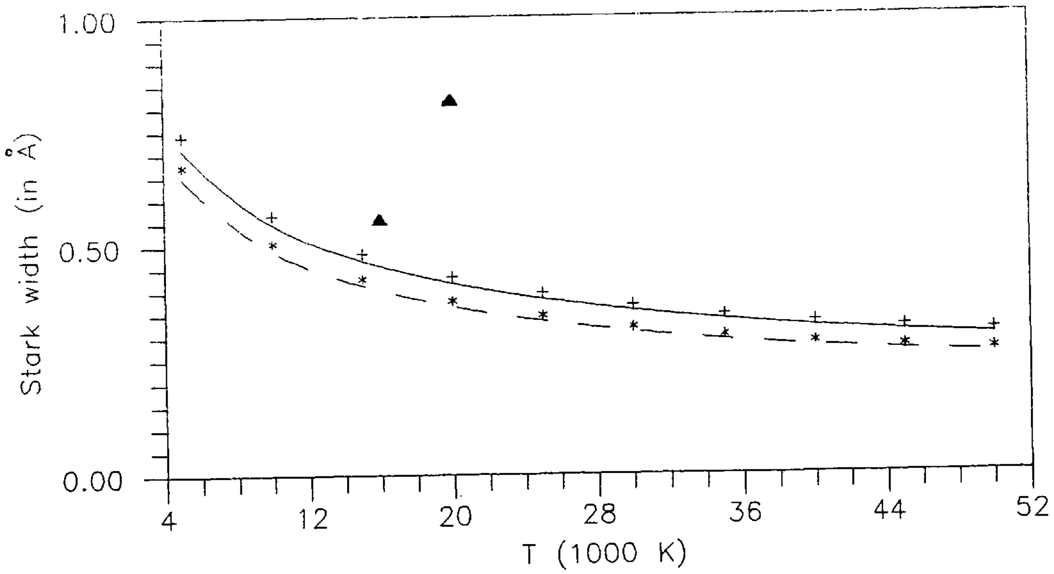

Fig. 1. Stark width (HWHM) for Bi II 5209 Å ($7s^3P_1^0 - 7p^3D_2$) spectral line as a function of temperature (T), at electron density N=10^{17} cm^{-3}.
The used notation is: (—) - present result with E_{ion}=127 000 cm^{-1}; (- - -) - present results with E_{ion}=134 600 cm^{-1}; (+ + +) - E_{ion}=127 000 cm^{-1} and pure LS coupling assumption; (* * *) - E_{ion}=134 600 cm^{-1} and pure LS coupling assumption; ⊕ - estimate of Lakićević (1983); ▲ - experimental data of Purić et *al.* (1985).

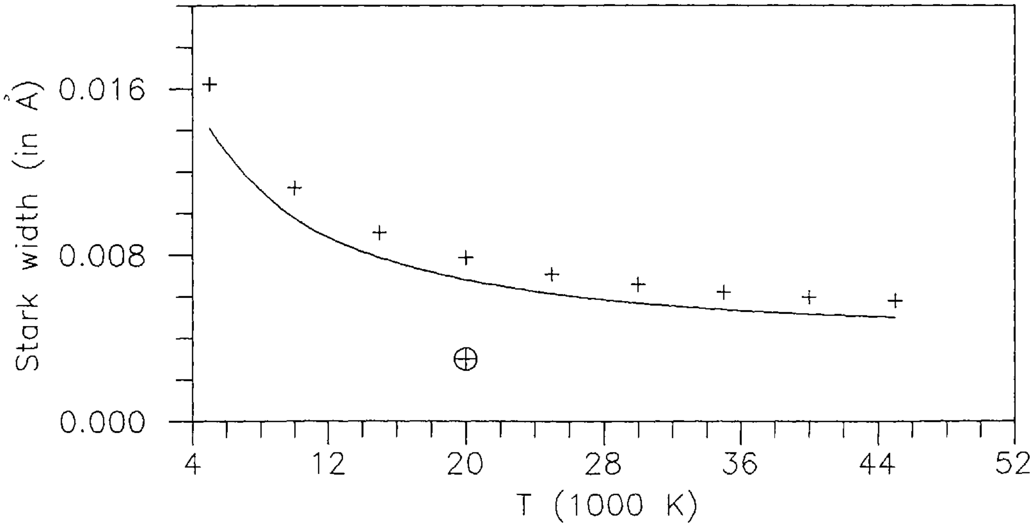

Fig. 2. Same as in Fig. 1. but for Bi II 1436.83 Å spectral line ($6p^2\ ^3P_0 - 7s\ ^3P_1^0$).

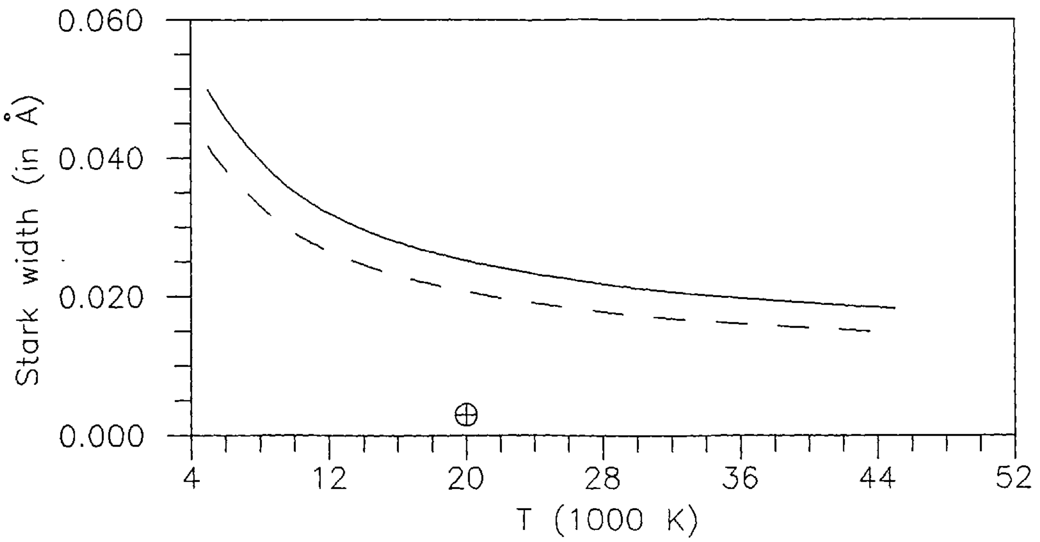

Fig. 3. Same as in Fig. 1. but for Bi II 1325.46 Å spectral line (6p^2 ^{3}P$_1$ – 7s^{3}P$_2$).

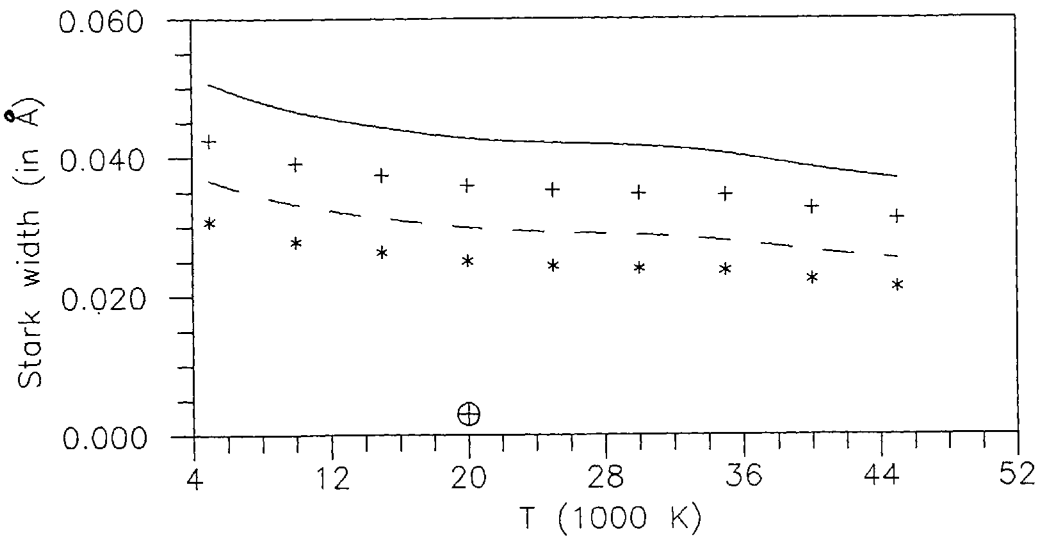

Fig. 4. Same as in Fig. 1. but for Bi II 1372.61 Å spectral line (6p^2 ^{3}P$_2$ – 7s ^{1}P$^0_1$).

where $\vec{R}^2_{jj'}$ $(j = i, f)$ is the square of the coordinate operator matrix element

$$\vec{R}^2_{l,l'} \approx (\frac{3n^*}{2Z})^2 \frac{max(l,l')}{2l+1}[n^{*2} - max^2(l,l')]\varphi^2 \qquad (2)$$

$$\sum_{j'}(\vec{R}^2_{jj'})_{\Delta n \neq 0} \approx (\frac{3n^*}{2Z})^2 \frac{1}{9}(n_j^{*2} + 3l_j^2 + 3l_j + 11). \qquad (3)$$

In Eqs. 1–3 with i, f, i', f' are denoted initial and final level respectively and their corresponding perturbing levels, l_j is the angular momentum quatum number, φ is the Bates–Damgaard factor (Bates and Damgaard, 1949; Oertel and Shomo, 1968), g

factors, $x_{j,j'} = 3kT/2|\Delta E_{j,j'}|$ $(\Delta E_{jj'} = E_{j'} - E_j)$, T is electron temperature, $x_{n_j} = 3kTn_j^{*3}/4Z^2E_H$ (E_H is hydrogen ionization energy, Z is residual ionic charge, $Z = 1$ for neutrals, 2 for single charged ions, etc.), $n_j^* = [E_H Z^2/(E_{ion} - E_j)]^{1/2}$ is effective principal quantum number (E_{ion} is appropriate spectral series limit), and N is electron density.

For $6p^2 - 6p7s$ transitions we derived the needed Bates and Damgaard factors φ from oscillator strengths calculated by Gruzdev (1968). Moreover, Gruzdev demonstrated that departure form LS coupling of $6p^2$ and 6p7s terms may be taken into account by representing the corresponding term as, a mixture of singlet and triplet states, and provided corresponding partition coefficient. For example $6p^2\ {}^3P_2$ may be represented as a mixture of K_1 $6p^2\ {}^3P_2$ and K_2 $6p^2\ {}^1D_2$, where $K_1 + K_2 = 1$. We calculated the corresponding squares of the coordinate operator matrix element in the form

$$\vec{R}^2_{jj'} = K_\alpha \cdot \vec{R}^2_{jj'} + K_\beta \cdot \vec{R}^2_{\alpha\alpha'}$$

where with α, α' are denoted the part with other multiplicity and the corresponding perturbing levels.

RESULTS AND DISCUSSION

Results for half width at halfmaximum for four Bi II lines are presented in Figs. 1 – 4 and compared with existing experimental data (Purić et al., 1985) as well as with the simple estimation of Lakićević (1983) based on regularities and systematic trends. In the case of Bi II spectrum exist an additional uncetrainty. Namely the ionization potential (E_{ion}) of 134600 cm^{-1} given in Moore's tables (1971) is too high according to Gruzdev's analysis (1968); who suggest a lower value of 127000 cm^{-1}. In Figs. 1 – 4 with solid line are denoted results obtained by E_{ion}=127 000 cm^{-1} and with dashed line result obtained with E_{ion}=134 600 cm^{-1}. With crosses and asterisks aree denoted calculation with two E_{ion} respectively, when pure LS coupling is assumed. We can see that the influence of both factors depends on transition. Taking into account that the accuracy of presented estimates is low due to complexity of the Bi II spectrum, these differences might give an impression on the accuracy of Bi II Stark width data.

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The Modified Semiempircal Approach for the Stark Widths of Complex Ion Lines of Astrophysical Interest

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Abstract. We have applied the modified semiempirical approach for calculation of Stark line widths of several complex ions. Our results are compared with available experimental data. The average ratio of experimental and theoretical Stark widths is $w_{\rm exp}/w_{\rm th} \approx 1.4 \pm 0.3$.

1. Introduction

A large number of heavy ion spectral lines have been observed in stellar spectra (see e. g., Jacobs & Dworetsky 1982, Sadakane et al. 1988, Fuhrmann 1989, Danezis et al. 1991). Stark broadening is the dominant pressure broadening mechanism for stars with $T_{\rm eff} > 10000$ K. Stark broadening of lines originating from energy levels with high principal quantum numbers may be important even for cooler stars (e. g., Vince et al. 1985).

In some cases, due to the lack atomic data, approximate methods are very useful for providing Stark broadening data. One of such methods is the modified semiempirical approach (MSE) developed by Dimitrijevic & Konjevic (1980). Here we report the results of our investigation of the applicability of the modified semiempirical approach for Stark line width calculations for some heavy ions: Zn II, Cd II, Bi II, As II, Sb II, I II, and Br II.

2. Theory

For ions with complex spectra the MSE approach gives for Stark width the following relation

$$w_{MSE} = N\frac{8\pi}{3}\frac{\hbar^2}{m^2}\left(\frac{2m}{\pi kT}\right)\frac{\pi}{\sqrt{3}}\cdot\Big\{\sum_{\ell_i\pm 1}\sum_{A'J'}\vec{\Re}^2(\ell_i AJ,\ell_i\pm 1A'J')\widetilde{g}(x_{JJ'})+$$
$$+\sum_{\ell_f\pm 1}\sum_{A'J'}\vec{\Re}^2(\ell_f AJ,\ell_f\pm 1A'J')\widetilde{g}(x_{JJ'})+\sum_{i'}(\vec{R}^2_{ii'})_{\Delta n\neq 0}g(x_{n_i})+ \qquad (1)$$
$$+\sum_{f'}(\vec{R}^2_{ff'})_{\Delta n\neq 0}g(x_{n_i})\Big\},$$

where the square of matrix element $(\vec{\Re}^2(\ell_j AJ,\ell_j\pm 1A'J'),\quad j=i,f)$ is

$$\vec{\Re}^2(\ell_j AJ,\ell_j\pm 1A'J')=\frac{\ell_>}{2J+1}Q(\ell A,\ell' A')Q(J,J')[R^{n'\ell'}_{n\ell}]^2 \qquad (2)$$

and

$$\sum_{j'} R^2_{jj'} = R^2_{\ell_j} - \sum_{\ell_j \pm 1} \sum_{A'J'} \Re^2(\ell_j AJ, \ell_j \pm 1 A'J'), \qquad (3)$$

where

$$R^2_{\ell_j} = \frac{1}{2}\left(\frac{n}{Z}\right)^2 [n^2 + 1 - 3\ell(\ell + 1)] .$$

In Equations (1 to 3), N and T are the electron density and temperature, respectively. Q(ℓA, ℓA') and Q(J, J') are factors which depend on the coupling approximation (see e.g., Sobelman 1979), where the quantum number A depends on the coupling approximation, e.g., in case of LS coupling approximation A = L, for jK approximation A = K, etc. $[R^{n'\ell'}_{n\ell}]$ is the radial integral, g(x) and $\tilde{g}$ (x) are the semiempirical (Griem 1968) and the modified semiempirical (Dimitrijevic & Konjevic 1980) Gaunt factors, respectively.

3. Results and Discusion

Using the MSE approach we have calculated Stark widths for several lines of Zn II, Cd II, Bi II, As II, Sb II, I II, and Br II. Our derived results for the Stark widths of 31 lines of these ions have been compared with the available experimental data (Miller & Bengston 1980, Puric et al. 1985, Labat et al. 1990, Labat et al. 1991, Djenize et al. 1991) and other estimates (Djenize et al. 1993, only in the case of As II). Table 1 contains the average ratios of theoretical and experimental Stark widths ($(w_{exp}/w_{th})_{Av.}$)

Table 1. Average ratios of theoretical (obtained by using the MSE approach) and experimental Stark width. W_{exp} and W_{th} are experimental and theoretical full line width (FWHM), respectively.

Ions	$(w_{exp}/w_{th})_{Av.}$	Number of Lines
Zn II	1.1	6
As II	1.2	1*
Br II	1.6	7
Cd II	0.8	8
Sb II	1.6	2
Sb III	1.6	2
Bi I I	1.4	5

* Estimate given by Djenize et al. (1993) based on the regularities and systematic trends

The average ratio of experimental and theoretical Stark widths of the considered ion lines is ≈ 1.4 ± 0.3. Taking into account the complexity of these ionic spectra, our results are mostly in "fair" agreement with experimental data for Stark widths.

Thus the MSE approach provides satisfactory accuracy for most astrophysical purposes even for heavier ions, as, for example, those considered in this paper.

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On The Stark Broadening of Na IX Spectral Lines

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and He III-impact line widths and shifts for 8 Na IX multiplets. The influence of the perturber charge on the ion broadening contribution has been investigated and discussed.

1. Introduction

The development of UV astronomy from space as well as the development of studies concerning the physics of stellar interiors (Seaton 1987) increases the significance of multiply charged ion lines in astrophysics as well as the corresponding Stark broadening data.

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969a,b), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 8 Na IX multiplets, to continue our effort to provide to astrophysicists the needed multiply charged ion line Stark broadening parameters, with a special emphasis on the lithium isoelectronic sequence. A summary of the formalism is given in Dimitrijevic et al. (1991). Here, we present and discuss the derived results. Moreover, the influence of the perturber charge on the ion broadening contribution has been investigated and discussed.

2. Results And Discussion

Energy levels for Na IX lines have been taken from Martin & Zalubas (1980). Oscillator strengths have been calculated by using the method of Bates & Damgaard (1949) and the tables of Oertel & Shomo (1968). For higher levels, the method described by Van Regemorter et al. (1979) has been used. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton- and He III (alpha particle-) impacts have been calculated.

Our results for 8 Na IX multiplets are shown in Table 1 for a perturber density of 10^{19} cm^{-3} and temperatures between 200,000 K and 2,000,000 K. The accuracy of these results decreases when broadening by ionic interactions becomes important.

In Figures 1 to 4, the influence of perturber charge on the ionic broadening contribution is analyzed. Full half widths (W) and shifts (d) due to Na IX collisions with Na ions with the charge between 1 and 9 (Z = 2 to 10) are compared with the electron- and proton-impact widths and shifts. When the perturber charge increases, the repulsive force between the emitter and the perturber increases as well. On the other hand, a perturber with higher charge has a stronger influence on the emitter than a perturber with smaller charge at the same distance. For lower temperatures, i. e., smaller perturber velocities, the repulsive force is more effective since the collision duration is longer and a highly charged perturber has a smaller chance to come closer to the emitter. Consequently, for the lower temperatures (Figures 1 and 2) the Stark broadening parameters vary less with Z than for $T = 10^6$ K (Figures 3 and 4). One can see as well that the shifts are more sensitive to the perturber charge increase than the widths.

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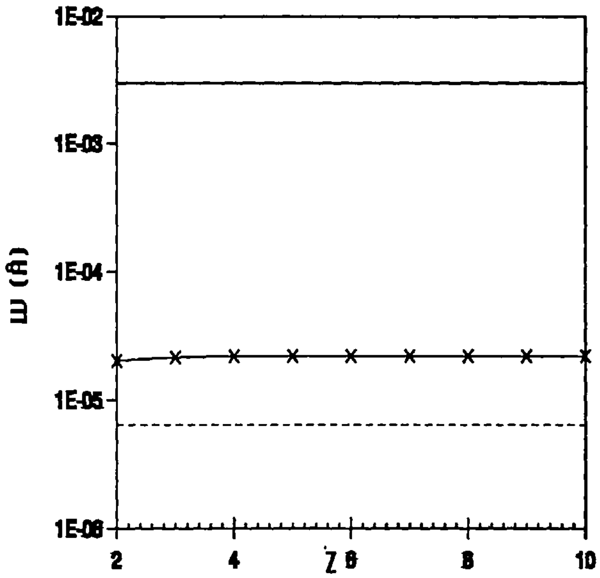

Fig. 1. The behavior of W(FWHM)[Å] for Na Z - Na IX impacts (-x-x-x-) (Z=1 for neutrals, 2 for singly charged ions, etc). Electron-impact (_____) and proton-impact (----) widths are shown as well. The considered transition is 2s-2p, electron density 10^{17} cm^{-3} and temperature 200,000 K.

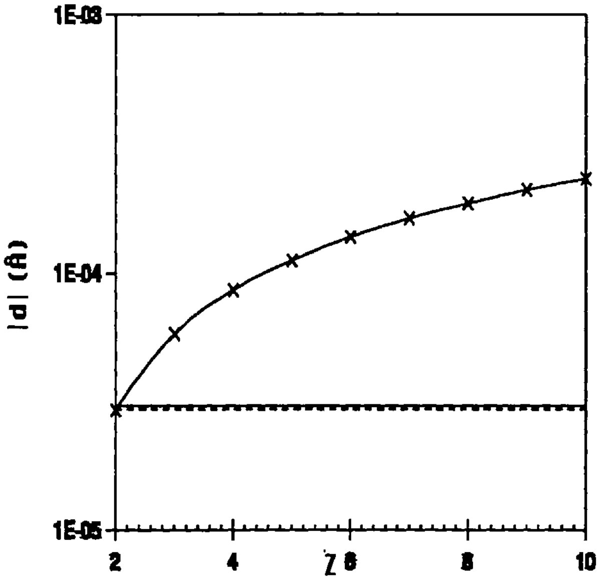

Fig. 2. Same as in Figure 1 but for the corresponding shift.

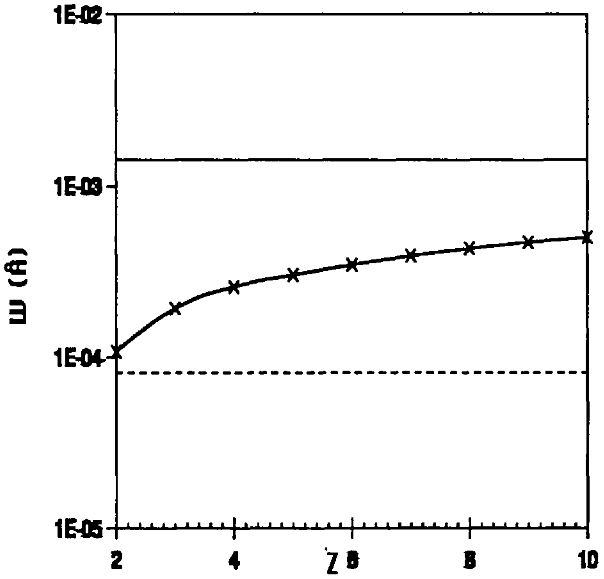

Fig. 3. Same as in Figure 1 but for a temperature of 1,000,000 K.

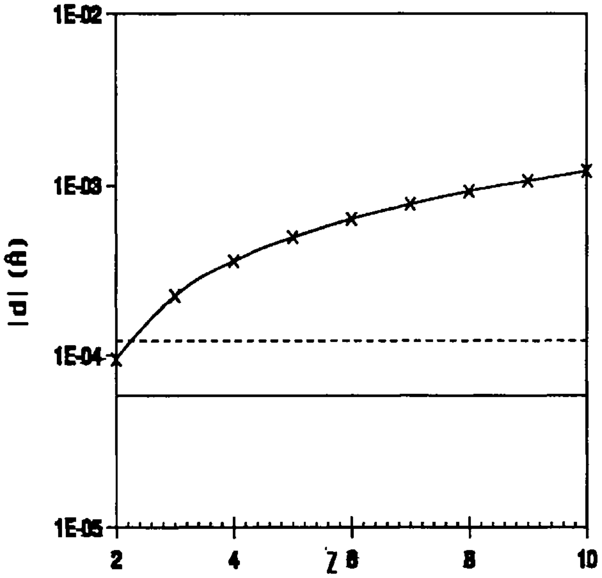

Fig. 4. Same as in Figure 3 but for the corresponding shift.

1995ASPC...78..169D

Table 1. The electron-, proton-, and He III- impact broadening parameters for Na IX for a perturber density of 10^{19} cm^{-3} and temperatures from 200,000 K to 2,000,000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By using c (see Equation (5) in Dimitrijevi et al. 1991), we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used. The asterisks identify cases for which the collision volume multiplied by the perturber density (the condition for validity of the impact approximation) lies between 0.1 and 0.5.

PERTURBER DENSITY = 0.1 E^{+20} cm^{-3}

TRANSITION	T (K)	Electrons		Protons		He III	
		Width (Å)	Shift (Å)	Width (Å)	Shift (Å)	Width (Å)	Shift (Å)
Na IX 2S-2P	200000	0.304E-01	-0.455E-03	0.641E-04	-0.285E-03	0.120E-03	-0.538E-03
684.8 Å	500000	0.196E-01	-0.513E-03	0.312E-03	-0.712E-03	0.599E-03	-0.142E-02
C=0.68E+22	1000000	0.142E-01	-0.582E-03	0.812E-03	-0.121E-02	0.158E-02	-0.244E-02
	2000000	0.106E-01	-0.550E-03	0.149E-02	-0.173E-02	0.296E-02	-0.350E-02
Na IX 2S-3P	200000	0.120E-02	0.136E-04	0.273E-04	0.433E-04	0.525E-04	0.819E-04
70.6 Å	500000	0.812E-03	0.125E-04	0.725E-04	0.811E-04	0.144E-03	0.163E-03
C=0.71E+19	1000000	0.618E-03	0.110E-04	0.117E-03	0.112E-03	0.235E-03	0.227E-03
	2000000	0.479E-03	0.838E-05	0.151E-03	0.134E-03	0.307E-03	0.273E-03
Na IX 3S-3P	200000	1.95	-0.306E-01	0.246E-01	-0.530E-02	0.467E-01	-0.100E-01
2500.6 Å	500000	1.34	-0.409E-01	0.591E-01	-0.130E-01	0.115	-0.259E-01
C=0.89E+22	1000000	1.04	-0.412E-01	0.861E-01	-0.214E-01	0.169	-0.433E-01
	2000000	0.816	-0.420E-01	0.105	-0.298E-01	0.209	-0.603E-01
Na IX 2P-3S	200000	0.905E-03	0.568E-04	0.187E-04	0.655E-04	0.363E-04	0.124E-03
81.3 Å	500000	0.622E-03	0.671E-04	0.745E-04	0.120E-03	0.150E-03	0.241E-03
C=0.26E+20	1000000	0.480E-03	0.664E-04	0.135E-03	0.165E-03	0.271E-03	0.334E-03
	2000000	0.378E-03	0.633E-04	0.189E-03	0.199E-03	0.381E-03	0.401E-03
Na IX 2P-4S	200000	0.126E-02	0.153E-03	0.129E-03	0.201E-03	*0.259E-03	*0.373E-03
59.0 Å	500000	0.913E-03	0.151E-03	0.276E-03	0.309E-03	*0.556E-03	*0.621E-03
C=0.57E+19	1000000	0.730E-03	0.148E-03	0.367E-03	0.376E-03	0.753E-03	0.770E-03
	2000000	0.588E-03	0.125E-03	0.445E-03	0.452E-03	0.931E-03	0.902E-03
Na IX 2P-5S	200000	0.247E-02	0.336E-03	*0.466E-03	*0.549E-03		
52.5 Å	500000	0.184E-02	0.354E-03	*0.752E-03	*0.763E-03		
C=0.22E+19	1000000	0.148E-02	0.325E-03	0.956E-03	0.918E-03		
	2000000	0.120E-02	0.264E-03	0.114E-02	0.107E-02		
Na IX 3P-4S	200000	0.298E-01	0.224E-02	0.191E-02	0.292E-02	0.379E-02	0.546E-02
235.6 Å	500000	0.212E-01	0.221E-02	0.406E-02	0.455E-02	0.817E-02	0.910E-02
C=0.79E+20	1000000	0.168E-01	0.217E-02	0.539E-02	0.554E-02	*0.110E-01	*0.113E-01
	2000000	0.134E-01	0.184E-02	0.682E-02	0.653E-02	*0.142E-01	*0.133E-01
Na IX 3P-5S	200000	0.265E-01	0.293E-02	*0.411E-02	*0.485E-02		
157.3 Å	500000	0.195E-01	0.309E-02	*0.666E-02	*0.674E-02		
C=0.20E+20	1000000	0.156E-01	0.284E-02	0.845E-02	0.810E-02		
	2000000	0.126E-01	0.230E-02	0.101E-01	0.940E-02		

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Stark Broadening of Al XI Spectral Lines

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and He III-impact line widths and shifts for 7 Al XI multiplets. The results have been used for the study of the behavior of Stark broadening parameters within an isoelectronic sequence.

1. Introduction

Due to theoretical simplicity (one optical electron), Stark broadening parameters for spectral lines of ions within the lithium isoelectronic sequence have a particular importance for the investigation of regularities and systematic trends. The results of such investigations are of interest for the acquisition of new data by interpolation and for the critical evaluation of existing experimental and theoretical data, particularly in astrophysics. Moreover, the astrophysical importance of multiply charged ion lines is increasing due to the development of UV astronomy from space and due to increasing research on the physics of stellar interiors (Seaton 1987).

To provide astrophysicists with the needed Stark broadening parameters, we have calculated electron-, proton-, and He III-impact line widths and shifts for 7 Al XI multiplets. The evaluation of the Stark broadening parameters has been performed by using the semiclassical-perturbation formalism (Sahal-Bréchot 1969a,b). A summary of the formalism is given in Dimitrijevic et al. (1991). Here, we discuss the results obtained as well as the Stark broadening parameter behaviour within the lithium isoelectronic sequence.

2. Results and Discussion

Energy levels for Al XI lines have been taken from Martin & Zalubas (1979). In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton- and He III- (alpha particle-) impacts have been calculated.

Our results for 7 Al XI multiplets for a perturber density of 10^{18} cm^{-3} and temperatures between 500,000 K and 4,000,000 K are presented in Table 1.

As an illustration, the behaviour of reduced electron- and proton-impact shifts d, i. e., shifts divided by the square of the transition wavelength, within the lithium isoelectronic sequence is shown in Figure 1. We can see that the behaviour is regular. This fact might be of interest for the interpolation of new data and for the critical selection of existing results.

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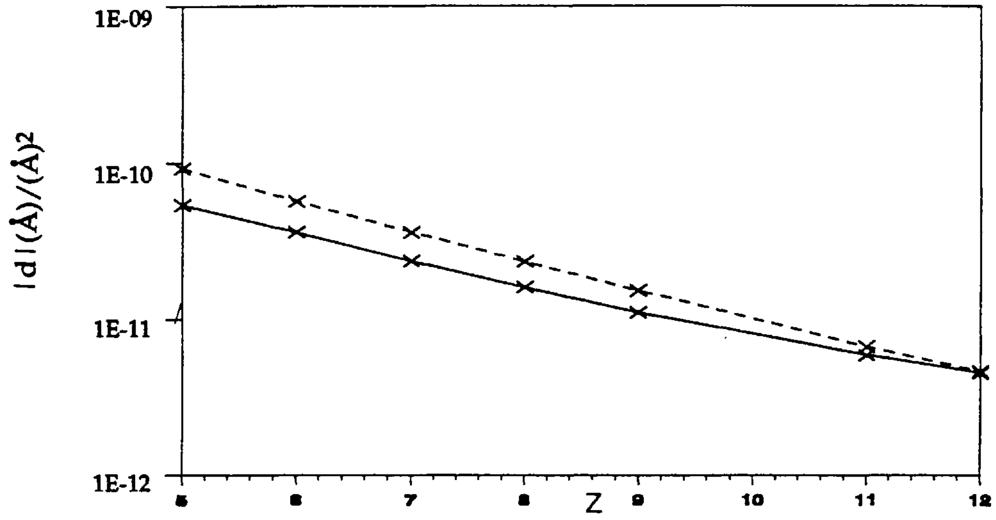

Fig. 1. The behavior of the reduced shift $|d|(\text{Å})/(\text{Å})^2$ for(——) electron- and (----) proton-impact for the 2s-2p transition along the lithium isoelectronic sequence. Z denotes the residual charge as "seen" by the optical electron (Z = 1 for neutrals, 2 for singly charged ions, etc.). The electron density is 10^{17} cm^{-3} and the temperature 500,000 K.

Table 1. The electron-, proton-, and He III- impact broadening parameters for several multiplets of Al XI for a perturber density of 10^{18} cm^{-3} and temperatures from 500,000 K to 4,000,000 K. Transitions and averaged wavelengths for the multiplets (in Å) are also given. By using c (see Equation (5) in Dimitrijevic et al. 1991), we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

		PERTURBER DENSITY = 0.1 E+19 cm-3					
		Electrons		Protons		He III	
TRANSITION	T (K)	Width (Å)	Shift(Å)	Width (Å)	Shift(Å)	Width (Å)	Shift(Å)
Al XI 2S-2P	500000	0.101E-02	-0.193E-04	0.561E-05	-0.216E-04	0.107E-04	-0.432E-04
554.4Å	1000000	0.761E-03	-0.228E-04	0.187E-04	-0.404E-04	0.363E-04	-0.811E-04
C=0.55E+21	2000000	0.557E-03	-0.221E-04	0.463E-04	-0.650E-04	0.914E-04	-0.131E-03
	4000000	0.416E-03	-0.202E-04	0.795E-04	-0.903E-04	0.158E-03	-0.182E-03
Al XI 2S-3P	500000	0.297E-04	0.342E-06	0.136E-05	0.196E-05	0.266E-05	0.394E-05
48.3Å	1000000	0.223E-04	0.298E-06	0.254E-05	0.286E-05	0.504E-05	0.577E-05
C=0.43E+18	2000000	0.169E-04	0.246E 06	0.405E-05	0.379E-05	0.810E-05	0.769E-05
	4000000	0.131E-04	0.174E-06	0.510E-05	0.455E-05	0.103E-04	0.923E-05
Al XI 2P-3S	500000	0.199E-04	0.189E-05	0.119E-05	0.300E-05	0.236E-05	0.603E-05
54.3Å	1000000	0.155E-04	0.177E-05	0.275E-05	0.433E-05	0.549E-05	0.873E-05
C=0.15E+19	2000000	0.121E-04	0.171E-05	0.493E-05	0.556E-05	0.990E-05	0.113E-04
	4000000	0.949E-05	0.148E-05	0.650E-05	0.666E-05	0.132E-04	0.136E-04
Al X1 2P-4S	500000	0.276E-04	0.413E-05	0.565E-05	0.836E-05	0.114E-04	0.169E-04
39.6Å	1000000	0.221E-04	0.393E-05	0.937E-05	0.105E-04	0.190E-04	0.213E-04
C=0.33E+18	2000000	0.177E-04	0.355E-05	0.124E-04	0.125E-04	0.253E-04	0.255E-04
	4000000	0.142E-04	0.286E-05	0.157E-04	0.148E-04	0.317E-04	0.301E-04
Al XI 2P-5S	500000	0.551E-04	0.100E-04	0.198E-04	0.223E-04	0.401E-04	0.450E-04
352Å	1000000	0.446E-04	0.944E-05	0.264E-04	0.268E-04	0.534E-04	0.543E-04
C=0.12E+18	2000000	0.360E-04	0.769E-05	0.333E-04	0.315E-04	0.672E-04	0.642E-04
	4000000	0.287E-04	0.61 5E-05	0.392E-04	0.361 E-04	0.788E-04	0.739E-04
Al XI 3P-4S	500000	0.670E-03	0.600E-04	0.826E-04	0.121E-03	0.165E-03	0.244E-03
157.3Å	1000000	0.524E-03	0.571E-04	0.137E-03	0.152E-03	0.280E-03	0.308E-03
C=0.45E+19	2000000	0.414E-03	0.516E-04	0.182E-03	0.183E-03	0.373E-03	0.372E-03
	4000000	0.330E-03	0.417E-04	0.228E-03	0.216E-03	0.463E-03	0.438E-03
Al XI 3P-5S	500000	0.597E-03	0.874E-04	0.174E-03	0.196E-03	0.35sE-03	0.396E-03
105.3A	1000000	0.477E-03	0.821E-04	0.234E-03	0.237E-03	0.473E-03	0.478E-03
C=0.11E+19	2000000	0.382E-03	0.668E-04	0.294E-03	0.278E-03	0.593E-03	0.565E-03
	4000000	0.304E-03	0.534E-04	0.348E-03	0.320E-03	0.693E-03	0.643E-03

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Stark Broadening of Mg I Spectral Lines of Astrophysical Interest

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, Mg II-, Si II-, Ar II-, and Fe II-impact line widths and shifts for 267 Mg I multiplets. The resulting data have been compared with existing experimental and theoretical values.

1. Introduction

Lines of neutral magnesium are present in the solar spectrum and the corresponding Stark broadening parameters are of interest for their analysis as well as for the diagnostic of solar plasma. Especially the infrared lines of Mg I have been observed in the solar spectrum at Kitt Peak and during the ATMOS experiment on Spacelab 3 (Brault & Noyes 1983, Farmer & Norton 1989, Jefferies 1991). It is well known that the contribution of the Stark broadening to the total broadening increases rapidly with the principal quantum number. Therefore the corresponding Stark widths and shifts are of importance for the structure of the solar atmosphere diagnostics.

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969a, b) we have calculated electron-, proton-, Mg II-, Si II-, Ar II-, and Fe II-impact line widths and shifts for 267 Mg I multiplets. A summary of the formalism is given in Dimitrijević & Sahal-Bréchot (1984). Here, we discuss the results for Mg I, along with a comparison with experimental data (Kusch & Schweicker 1976, Goldbach et al. 1982, Helbig & Kusch 1972) and other theoretical results (Brissaud et al. 1976, Griem 1974).

2. Results and discussion

Our results for perturber densities of 10^{11} cm^{-3} – 10^{19} cm^{-3}, and temperatures, T = 2,500 - 50,000 K, will be published elsewhere (Dimitrijević & Sahal-Bréchot 1994). In Table 1, the present results are compared with experimental data (Kusch & Schweicker 1976, Goldbach et al. 1982, Helbig & Kusch 1972) and with semiclassical calculations of Griem (1974). According to our checks, the impact approximation is not applicable for ion broadening contribution, for the experimental plasma conditions of Table 1. Consequently, in all cases the quasistatic broadening contribution has been included by using the quasistatic ion broadening parameter given in Griem (1974). One can see that present calculations are in better agreement with experimental widths, while shift calculations mutually agree but show large differences with experimental shifts. For Mg I $3s^2\,^1S - 3p\,^1P^o$, there exist also the MMM semiclassical results (Brissaud et al. 1976). The ratio of experimental and MMM widths is 0.68 at T = 12970 K and 0.76 at 13370 K. New high precision measurements for different temperatures and other Mg I lines are needed for checking and improving the semiclassical theoretical approach.

Table 1. Experimental (Wm) Stark Widths (FWHM) and (dm) Shifts in Å for Mg I lines, compared with the theory (WDSB: the present semi-classical calculations, WG: Griem 1974). The last column gives the reference (Ref*).

Transition/ Wavelength [Å]	T [K]	Ne [10^{17} cm^{-3}]	Wm	Wm WDSB [Å]	Wm WG	dm	dm dDSB [Å]	dm dG	Ref (*)
3p ^{1}P^o-4d ^{1}D 5528.41 Å	10000	1.	4.28	1.00	0.72	1.88	0.64	0.55	(3)
3p ^{1}P^o-5d ^{1}D	10000	1.	8.44	0.92	0.61	1.98	0.33	0.26	(3)
4702.99 Å	10000	1.	7.2	0.78	0.52	1.62	0.27	0.21	(2)
3s^2 ^{1}S-3p ^{1}P^o	12970	1.10	0.054	0.63	0.51				(2)
2852.13 Å	13370	1.28	0.071	0.70	0.57				(2)

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*) References:
(1) Kusch & Schweicker (1976),
(2) Goldbach et al. (1982),
(3) Helbig & Kusch (1972).

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PROGRAM AND ABSTRACTS

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spectral absorption due to these processes together with the corresponding molecular photo-dissociation processes, in the atmosphere of the Sun and some DB white dwarfs. The standard models of the considered atmospheres have been used in the calculations. It has been established that the examined processes generate rather wide and firm molecular absorption bands in the UV and VUV regions, which should be taken into account at interpretation of the data obtained from measurements.

AOB (ASTRONOMICAL OBSERVATORY – BELGRADE) NODE OF THE VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Zoran Simić[2],
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We will consider and discuss actual status and plans for the future development and activity of Serbian AOB (Astronomical Observatory – Belgrade) Node of Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project: Also, we will discuss activities, needed that AOB Node of VAMDC becomes a regional center for the connection of activities on atomic and molecular data, and an organizer of regional trainings for students and potential users, as well as a VAMDC Node for monitoring the needs of users in South Eastern Europe.

ON THE ELECTRON IMPACT BROADENING OF DOUBLY CHARGED MAGNESIUM ION LINES

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PROGRAM AND ABSTRACTS

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Society of astronomers of Serbia and
Group for Astrophysical Spectroscopy, Belgrade 2011

ABSTRACTS

INVITED LECTURES

SPECTROSCOPY AS A TOOL FOR DETECTION OF SUPERMASSIVE BINARY BLACK HOLES

Luka Č. Popović

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia,

Spectroscopy can be very useful in detection of super-massive binary black holes. Here we will discuss the possible emission of gas around binary black hole, and consider the changes in spectra (narrow and broad spectral lines) due to the existence of such objects.

VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND AOB NODE. PRESENT STATUS AND PERSPECTIVES

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Darko Jevremović[2],
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[5]LUTH, Observatoire de Paris, France

Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project with the objective to create a secure, documented, flexible and interoperable e-science environment-based interface to existing atomic and molecular data, will be presented in this review. It will also provide a forum for dissemination and training of potential users.

Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela.

The VAMDC facilities will be first of all useful for Astronomy, Plasma science, Atmospheric Science Radiation science and Fusion community as well as Industries using technological plasmas and Lightning industry and will represent a powerful tool for a better and easier search for the needed atomic and molecular data and an efficace data mining.

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

In this lecture, we will consider VAMDC, a good example of the global collaborations and development of new facilities in e-science. Also, we will present AOB VAMDC Node and our plans for its further development.

STARK-B DATABASE AND VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC

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The database STARK-B is a collaborative project between Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon and the Astronomical Observatory of Belgrade. For the moment STARK-B contains Stark line broadening parameters (widths and shifts) obtained within the impact approximation using the semiclassical perturbation approach and the impact approximation. It is devoted for modelling and spectroscopic diagnostics of stellar atmospheres and envelopes, as well as for laboratory plasmas, laser equipment, inertial fusion plasma and technological plasmas.

STARK-B database is a part of the core of European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC) e-infrastructure, one of the databases upon which it is based.

In this review, the STARK-B database will be presented as well as its connection with VAMDC.

SERBIAN VIRTUAL OBSERVATORY, VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND ASTROINFORMATICS

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SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) started as a project whose funding was approved through a grant TR13022 from Ministry of Science and Technological Development of Republic of Serbia, with duration of 33 months from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed

I Workshop on
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PROGRAM AND ABSTRACTS

Edited by Milan S. Dimitrijević

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Group for Astrophysical Spectroscopy, Belgrade 2011

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

In this lecture, we will consider VAMDC, a good example of the global collaborations and development of new facilities in e-science. Also, we will present AOB VAMDC Node and our plans for its further development.

STARK-B DATABASE AND VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC

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by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". After establishing SerVO and starting to digitize and archive photo plates and other astronomical data produced at Belgrade Astronomical Observatory, the aims are: i) To work on the development of SerVO and to join the EuroVO and IVOA; b) To develop SerVO data Center which will work on the digitizing, archiving and publishing in VO format photo-plates; c) To work on the development of tools for visualization of data; d) Make a regional node of Virtual Atomic and Molecular Data Center – VAMDC; e) Make a mirror site of STARK-B - Stark broadening data base containing as the first step Stark broadening parameters, obtained within the semiclassical perturbation approach and impact approximation, in VO compatible format; f) Make a mirror site for DSED - Darthmouth Stellar Evolution Database in the context of VO, and g) to put online electronic editions of serbian astronomical institutions.

In this review, the SerVO will be presented, and its history, aims and future plans, as well as its connections with European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), and its node on Belgrade Astronomical Observatory will be considered.

RESULTS OF THE LONG-TERM SPECTRAL OPTICAL MONITORING OF THE ACTIVE GALAXY3 C390.3

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The structure of the broad line region (BLR) in active galactic nuclei (AGN) is still not well known. The BLR is close to the central supermassive black hole and may hold basic information about the formation and fueling of AGN, as well as of the mass of the black hole in the center.

The AGN are highly variable objects. Especially their broad emission lines (BEL) are changing dramatically. The investigation of the BEL flux and profile variability in a long period is very useful for mapping the geometrical and dynamical structure of the BLR.

Here we present the result of the long-term spectral optical monitoring of a well know radio-loud AGN 3c390.3 that exhibit interesting double-peaked BEL profiles.

Kiel/CCP7 WORKSHOP

on

ATMOSPHERES OF EARLY-TYPE STARS

September 18–20, 1991
University of Kiel, Germany

POSTER ABSTRACTS

P V.2

ION-ATOM COMPLEXES AND THE ABSORPTION OF RADIATION IN STELLAR PLASMA

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The significance of the combined study of the processess of the photodissociation

$$H_2^+ + \hbar\omega - H + H^+ \qquad (1a)$$

and the absorption of electromagnetic radiation by collisional ion-atom complexes

$$H + H^+ + \hbar\omega - \begin{cases} H + H^+ \\ H^+ + H \end{cases} \qquad (1b)$$

has been demonstrated recently by Mihajlov and Dimitrijević (1986), for the conditions characteristic for stellar plasma. The simple method for the determination of corresponding absorption coefficients in the infrared and visible spectral range, proposed in the mentioned article, is applicable not only in the case of (1a) and (1b) processess but for a more numerous class of atomic systems. For the application of this method, the potentials (as a function of the internuclear distance R) for low lying energy states of molecular ions and the corresponding dypole matrix elements are needed.

In Mihajlov and Dimitrijević (1986), the H_2^+ case is presented as an example for the application of the method and approximate expressions for H_2^+ molecular potentials were used. The accuracy of the proposed method is conditioned with the accuracy of the method for the calculation of the spontaneous emission during ion-atom collisions (as demonstrated in Mihajlov and Dimitrijević (1986)). Since it is demonstrated recently (Ermolaev et al, 1989; Ermolaev and Mihajlov, 1991), that the accuracy of the analogous method for spontaneous emission is better than assumed previously by authors, and cosequently the accuracy of the proposed method also, we provide here the corresponding absorption coefficients for the H_2^+ case obtained using the accurate molecular potentials for H_2^+, as well as the absorption coefficients for He_2^+ case for the conditions in non DA white dwarfs with helium atmospheres

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POSTER ABSTRACTS

P V.5

ON STARK LINE SHIFTS IN SPECTRA OF VERY HOT STARS

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Besides the large scale motions, in "quiet" atmospheres of hot stars, Stark shifts can be a competitive cause of observed line asymmetries and shifts (Kršljanin, 1989a,b).

Stark broadening parameters for all most important SiIV, CIV, NV and OVI lines (see Dimitrijević and Sahal-Bréchot, 1991 and references therein) have been calculated using the semiclassical -perturbation formalism (Sahal-Bréchot, 1969a,b).

Here are presented Stark shifts of a number of important ultraviolet lines (according to lists of Dean and Bruhweiler, 1985; Rogerson and Ewell, 1985) of the mentioned ions in atmospheres of O and B main sequence stars (Kurucz, 1979), subdwarfs and hot DA white dwarfs (Wesemael et al.,1980). Our results give an estimate of the Stark broadening contribution to the observed line shifts and asymmetries in spectra of these stars. In some cases we propose the relative line shifts to be easily compared with the observed ones (e.g. difference in Stark shifts between the weak NV (4p-5d) λ1549.30 Å line and the CIV resonance doublet equals 30mÅ in the spectrum of an OB subdwarf).

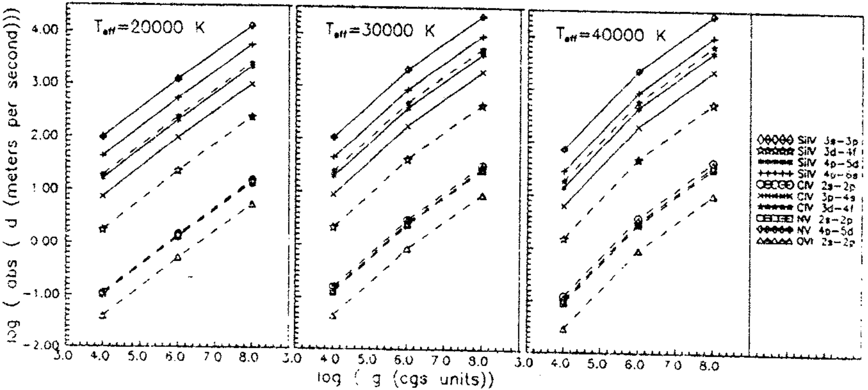

Fig.1. Stark shifts of ion lines from different multiplets at TAUross=0.5 in atmospheres of hot stars, as functions of surface gravity and effective temperature. Dashed lines denote blue shifts.

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STARK BROADENING DATA FOR ASTROPHYSICAL PLASMA INVESTIGATIONS

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Abstract

In the introductory part, a short review of astrophysical problems where Stark broadening data are of interest, is presented. Finally, a review of results of Belgrade group theoretical Stark broadening research within the semiclassical perturbation approach and the modified semiempirical method is presented.

stellar atmospheres – atomic processes, line profiles, stellar plasmas

1 Astrophysical interest for Stark broadening data

The interest for Stark broadening data of good quality for as large as possible number of spectral lines of various emitters is particularly stimulated in last ten years by the development of space astronomy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected. Consequently, the interest not only for abundant, but also for trace elements data increases.

There is a number of astrophysical problems where Stark broadening data are of interest. Such problems are e.g. the stellar spectra analysis and synthesis and stellar plasma investigation, diagnostics and modeling. Stark broadening is the main broadening mechanism in O, A and B type star atmospheres and white dwarfs (see e.g. Popović et al. 1999a).

The available abundance analysis for early-type stars show that about 10% - 20% of A and B stars have abundance anomalies, including anomalies in isotopic compositions (Lecrone et al. 1993). The abundance anomalies in these stars, called CP stars, have been caused by different hydrodynamical processes in the outer stellar layers (aided and mitigated by magnetic fields, weak stellar winds, turbulence, rotation mixing, etc.). In order to investigate these processes, atomic data for numerous lines of numerous emitters, including Stark broadening data, are needed, since the stellar chemical composition is not known a priori.

Such investigations, where Stark broadening data are of interest, provide us with useful information for modeling of stellar evolution. As an example, the abundances study in stellar atmospheres provides evidences for the chemical composition of the stellar primordial cloud, processes occurring within the stellar interior, and the dynamical processes in stellar atmospheres.

Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level and consequently, Stark broadening contribution may become significant even in the spectrum of Sun and cooler stars.

Reliable Stark broadening data are also needed for estimation of the radiative transfer through the stellar plasmas, especially in subphotospheric layers as well as for opacity calculations. In such a case data for especially large numbers of lines are needed. An illustrative example might be the article on the calculation of opacities for classical cepheid models (Iglesias et al. 1990), where 11,996.532 spectral lines have been taken into account(45 lines of H, 45 of He, 638 of C, 54 of N, 2390 of O, 16030 of Ne, 50170 of Na, 105700 of Mg, 145200 of Al, 133700 of Si, 12560 of Ar and 11,530.000 of Fe), and where Stark broadening is important.

Stark broadening is of interest as well for the radiative acceleration considerations, nucleosynthesis research and other astrophysical topics.

Not only in astrophysics, but also in physics and plasma technology, a number of problems depend on very extensive list of elements and line transitions with their atomic and line broadening parameters. One may mention as examples laboratory plasma diagnostic, research and modeling, radiative transfer calculations and investigation of laser produced plasmas (not only in laboratory but as well in industry during the laser welding, melting and evaporation of different targets), and plasmas created in fusion research (particularly inertial confinement and pellet compression fusion), development and modelling of lasers, as well as of light sources.

2 Semiclassical calculations of Stark broadening parameters

In spite of the fact that the most sophisticated theoretical method for the calculation of a Stark broadened line profile is the quantum mechanical strong coupling approach, due to its complexity and numerical difficulties, only a small number of such calculations exist (see e. g. references in Dimitrijević 1996).

In a lot of cases such as e.g. complex spectra, heavy elements or transitions between more excited energy levels, the more sophisticated quantum mechanical approach is very difficult or even practically impossible to use and, in such cases, the semiclassical approach remains the most efficient method for Stark broadening calculations.

In a series of papers we have performed large scale calculations of Stark broadening parameters for a number of spectral lines of various emitters (Dimitrijević, 1996, and references therein), within the semiclassical - perturbation formalism (Sahal-Bréchot, 1969ab), for transitions when a sufficiently complete set of reliable atomic data exists and a good accuracy of obtained results is expected. All innovations and optimizations of the computer code have been discussed several times (Fleurier et al. 1977; Dimitrijević et al. 1991, Dimitrijević and Sahal-Bréchot 1995, 1996a, 2000a)

In order to complete as much as possible Stark broadening data needed for astrophysical and laboratory plasma research and stellar opacities calculations we are making a continuous effort to provide Stark broadening data for a large set of atoms and ions. Extensive calculations have been performed, up to now (Dimitrijević, 1996, and references therein) for a number of radiators, and consequently, Stark broadening parameters for: 79 He I, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg (references in Dimitrijević 1996), 31 Se (Dimitrijević and Sahal-Bréchot 1996bc), 33 Sr (Dimitrijević and Sahal-Bréchot 1996de), 14 Ba (Dimitrijević and Sahal-Bréchot 1996f, 1997a), 189 Ca (Dimitrijević and Sahal-Bréchot 1999ab), 32 Zn (Dimitrijević and Sahal-Bréchot 1999de), 6 Au (Popović et al. 1999bc), 48 Ag (Dimitrijević and Sahal-Bréchot 2001), 28 Ca II, 30 Be II, 29 Li II, 66 Mg II (references in Dimitrijević 1996), 64 Ba II (Dimitrijević and Sahal-Bréchot 1996f, 1997a), 19 Si II, 3 Fe II, 2 Ni II (references in Dimitrijević 1996), 22 Ne II (Milosavljević et al. 2001), 12 B III (Dimitrijević and Sahal-Bréchot 1996gh), 23 Al III, 10 Sc III (references in Dimitrijević 1996), 27 Be III (Dimitrijević and Sahal-Bréchot

1996gh), 5 Ne III (Milosavljević et al. 2001), 32 Y III (Dimitrijević and Sahal-Bréchot 1997b, 1998a), 20 In III, 2 Tl III (Dimitrijević and Sahal-Bréchot 1998b, 1999c), 2 Ne IV (Milosavljević et al. 2001), 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV (references in Dimitrijević 1996), 114 P IV, 2 Pb IV (Dimitrijević and Sahal-Bréchot 1996i, 1997c), 19 O V, 30 N V, 25 C V, 51 P V (references in Dimitrijević 1996), 34 S V (Dimitrijević and Sahal-Bréchot 1997d, 1998c), 26 V V (Dimitrijević and Sahal-Bréchot 1998d), 30 O VI, 21 S VI (references in Dimitrijević 1996), 2 F VI (Dimitrijević and Sahal-Bréchot 1998e, 2000a), 14 O VII (Dimitrijević and Sahal-Bréchot 1998fg), 10 F VII (references in Dimitrijević 1996), 10 Cl VII (Dimitrijević and Sahal-Bréchot 1998e, 2000a), 20 Ne VIII (references in Dimitrijević 1996), 4 K VIII (Dimitrijević and Sahal-Bréchot 1998h, 1999f), Ar VIII (Dimitrijević and Sahal-Bréchot 1999g, 2000b), Kr VIII (Dimitrijević and Sahal-Bréchot 199h, 2000a), 4 Ca IX (Dimitrijević and Sahal-Bréchot 1997e, 1998i), 30 K IX (Dimitrijević and Sahal-Bréchot 1998h, 1999f), 8 Na IX (references in Dimitrijević 1996), 57 Na X (Dimitrijević and Sahal-Bréchot 1998jk), 48 Ca X (Dimitrijević and Sahal-Bréchot 1997e, 1998i), 4 Sc X (Dimitrijević and Sahal-Bréchot 1998lm), 7 Al XI (references in Dimitrijević 1996), 4 Si XI (Dimitrijević and Sahal-Bréchot 1997f, 1998n), 18 Mg XI, 4 Ti XI, 10 Sc XI, 9 Si XII (references in Dimitrijević 1996), 27 Ti XII (Dimitrijević and Sahal-Bréchot 1998lm), 61 Si XIII (Dimitrijević and Sahal-Bréchot 1997f, 1998n) and 33 V XIII (Dimitrijević and Sahal-Bréchot 1998d) multiplets become available.

Data for particular lines of F I (references in Dimitrijević 1996), B II, C III, N IV (Blagojević et al. 1999, Dimitrijević 1999), Ar II (Dimitrijević and Truong Bach 1986), Ga II, Ga III, Cl I, Br I, I I, Cu I, Hg II, N III, F V and S IV (references in Dimitrijević 1996) also exist.

The obtained semiclassical result have been compared with critically selected experimental data for 13 He I multiplets (Dimitrijević and Sahal-Bréchot, 1985). The agreement between experimental and all three semiclassical calculations is within the limits of ±20%, what is the predicted accuracy of the semiclassical method (Griem, 1974).

3 Stark broadening parameter calculations within the Modified semiempirical method

Whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important, simple approximate formulae with good average accuracy may be very useful. Moreover, in the case of more complex atoms or multiply charged ions the lack of the accurate atomic data needed for more sophisticated calculations, makes that the reliability of the semiclassical results decreases. In such cases approximate methods might be very interesting. One of the methods where the most complicated part of the calculation, the cross sections for the corresponding dipole transitions are calculated using averaged experimental data, is the modified semiempirical method, developed in Belgrade by Dimitrijević and Konjević 1980, 1981, 1987 and Dimitrijević and Kršljanin 1986, for radiators where there is not a sufficiently complete atomic data set for reliable semiclassical calculations.

In order to complete as much as possible the needed Stark broadening data, Belgrade group (Milan S. Dimitrijević, Luka Č. Popović, Vladimir Kršljanin, Dragana Tankosić, Nenad Milovanović) used the modified semiempirical method to obtain the Stark width and in some cases shift data for the most intensive lines for the following atom and ion species:

Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, La II, Au II, Eu II, Ti II, Kr II, Na II, Y II, Zr II, Sc II, Ra II, Be III, B III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III, La III, V III, Ti III, Bi III, Sr III, Cu III, Co III, Zr III, B IV, Cu IV, Ge IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI, and Cl VI.

When the modified semiempirical formula is not applicable due to the lack of atomic energy level data, the knowledge on regularities and systematic trends of line broadening parameters can be used for quick acquisition of new data especially when high accuracy of each particular value is not needed (see e.g. Wiese and Konjević, 1982);

In order to make the use of our results easier, our plan is to systematize them with BELDATA database.

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DIELECTRONIC CHEMI-IONIZATION AND CHEMI-RECOMBINATION ATOMIC PROCESSES IN STELLAR ATMOSPHERES

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Abstract

Semiclassical methods for dielectronic chemi-ionization and chemi-recombination atomic processes rate coefficient determination, are discussed as well as the results for conditions characteristic for stellar atmospheres weakly ionized layers. It was shown that in stellar atmospheres hydrogen and helium plasmas, the considered processes may have important or even dominant role in comparison with other ionization - recombination processes, for highly excited atomic states populations. Obtained results may be used for the modelling of equilibrium as well as non equilibrium weakly-ionized plasma within the large range of electronic and atomic temperatures.

stellar atmospheres – atomic processes: ionization, recombination

1 Introduction

It is well known that the atomic levels population determination in gas plasmas is a very significant problem, first of all for the optical but also for thermodynamical and transport properties of such plasmas. To solve such problems is simple if plasma is in local thermodynamic equilibrium (LTE). However, without LTE, atomic levels populations should be calculated in many cases by solving large systems of kinetic equations which describe all important collisional – radiative processes in the plasma of interest. In such calculations, first of all have been taken into account radiative and non radiative processes connected with the free electron scattering on atoms and atomic ions, and radiative processes conditioned by atomic particles interaction with free electromagnetic field (Bates 1962a,b, Burges and Summers, 1976). Moreover, dissociative recombination processes in the case of molecular ions in low lying rovibrational states and, some of chemi-ionization processes (namely associative and Penning ionization) conditioned by ground state atoms collisions with atoms in low lying excited states have been taken into account as well (Bates 1962ab. Aleksandrov et al 1974, Giusti-Suzor 1989, Klucharev 1993). The aim of this paper is to review recent results concerning a group of ionization-recombination processes treated here as chemi-ionization and chemi-recombination processes, which influence in astrophysical plasmas has been usually neglected up to now.

2 Chemi-Ionization and Chemi-Recombination Processes

It was shown in Mihajlov, Djurić and Dimitrijević (1996), Mihajlov, Dimitrijević and Djurić (1996) and Mihajlov et al (1997a), that in weakly ionized gas plasmas, the dielectronic recombination processes

$$e + A + A^{+} \Longrightarrow A + A^{*}(n) \tag{1}$$

and

$$e + A_2^{+}(v, J) \Longrightarrow A + A^{*}(n) \tag{2}$$

treated here as chemi - recombination processes, and their inverse collisional chemi-ionization processes

$$A + A^{*}(n) \Longrightarrow e + A + A^{+} \tag{3}$$

and

$$A + A^{*}(n) \Longrightarrow e + A_2^{+}(v, J) \tag{4}$$

may be very important and sometimes even dominant in comparison with other relevant ionization - recombination processes. We have in view here the influence of these processes on populations of Rydberg atoms in weakly ionized gas plasmas. In the equations for above mentioned processes e denotes free electron, A and A^{+} - atom and positive (singly charged) atomic ion in their ground states, $A^*(n)$ - atom in a highly excited (Rydberg) state with the principal quantum number $n >> 1$. $A + A^+$ - a collisional ion-atom system, which may be treated as quasi - molecular complex (within the internuclear distances range significant for the considered process), and $A_2^+(v, J)$ - molecular ion in one of the highly excited rovibrational states belonging to its ground electronic state. With v and J are denoted vibrational and rotational quantum numbers. It is assumed that at least one of them is high enough to ensure that the dissociation energy of the $A_2^+(v, J)$ state is relatively small compared to dissociation energy of the ground rovibrational state (typical dissociation energy of such rovibrational states is less than 1eV). Moreover, it is assumed that in the considered weakly ionized plasma subsystems formed by molecular ions $A_2^+(v, J)$ and ion-atom complexes $A+A^+$, are in dissociation-association equilibrium.

In connection with the dissociative - recombination channel (2), one should draw attention that this channel should not be identified with above already mentioned standard process of dissociative recombination, where molecular ions are in lower rovibrational states (belonging also to its ground electronic state). Namely, this standard dissociative recombination process, due to clear energetic reasons, practically does not influence on populations of atoms in Rydberg states (with $n >> 1$), since in such processes we have an atom A^* in one of low lying energetic states. However, just standard dissociation processes were considered until recently. Only in some papers, the dissociative recombination processes with molecular ions in highly excited rovibrational states were treated (Schneider et al 1994, Chibisov et al 1997), but only in hydrogen case and with a limited domain of applicability. For example, in Schneider et al (1994) the recombination of H_2^+ ions was considered (related to astrophysical plasmas) in temperature domains up to 4000K, while in so important case of astrophysical plasma (Solar photosphere) the temperature domain of interest is above that.

For the description of the considered chemi - recombination/ionization processes it one uses here the semiclassical method developed in previous articles, based on the mechanism of energy conversion within the electronic component of the atom - Rydberg atom or electron-ion-atom system, due to dipole interaction between an outer (weakly bound or free) electron and a quasi-molecular ion-atom subsystem. This approximation served before as a bases of the initial method for description of non-elastic atom – Rydberg atom collisional processes (Smirnov and Mihajlov 1971), and has been used than and for some of chemi - ionization processes (Devdariani et al 1978). The mentioned initial method has been modified latter, what enabled the development of the method used here, for the description above mentioned chemi - recombination and chemi - ionization processes. Basically, this method has been developed already in Janev and Mihajlov (1980), Mihajlov and Janev (1981), Mihajlov and Ljepojevic (1982), and Mihajlov, Ljepojević and Dimitrijević (1992), and obtained its final form in Mihajlov, Djurić and Dimitrijević (1996), Mihajlov, Dimitrijević and Djurić (1996), and Mihajlov et al (1997a). One should draw attention in relation with this basic approximation that just it enabled to interpret several experimental results related to chemi - recombination and chemi - ionization processes (see Klucharev and Vujnovic 1990, Klucharev 1993, Maurmann et al 1999, Chibisov et al 1997).

3 Results and Discussion

The chemi-recombination processes were investigated in the case of hydrogen plasma ($A = H$), earlier in Mihajlov and Ljepojević (1982) and in more detail in Mihajlov, Ljepojević and Dimitrijević (1992) and Mihajlov, Dimitrijević and Djurić (1996). To the same case are related results presented in Mihajlov et al (1997b) and Mihajlov, Ignjatović and Dimitrijević (1998), obtained in connection with concrete laboratory and astrophysical plasmas. Concerning astrophysical ones, we first of all have in view here hydrogen plasma of Solar atmosphere around the temperature minimum domain. Results of all mentioned articles show that the significance of chemi - recombination and chemi - ionization processes (1) - (4), as a factor influencing on hydrogen excited state populations, increases for the considered plasma when the departure from LTE increases. In particular layers of Solar atmosphere near temperature minimum the influence of these processes is even dominant in comparison with other relevant ionization-recombination processes.

The helium case, where rate coefficients for processes (1) - (4) are also known is even more important than hydrogen one since in laboratory conditions large departures from LTE are realized more easily. Such non-equilibrium helium plasmas in laboratory conditions were investigated experimentally e.g. in Aleksandrov, Gurevich and Podmoshenskij (1969), Aleksandrov et al (1974), Petrović and Crompton (1987), Milloy and Crompton (1977), and Solov'yanchik (1993). In astrophysics, we have such plasmas in atmospheres of some helium rich stars as e.g.

helium rich DB white dwarfs. Existing theoretical results (see Mihajlov, Dimitrijević and Djurić 1996, Mihajlov et al 1997a), demonstrate indeed that processes (1) - (4) in the weakly ionized non-equilibrium helium plasmas may have a particularly significant influence on the atomic excited state populations.

The present discussion demonstrates that the described chemi-recombination and chemi-ionization processes should be considered as factors whose influence on kinetics inside a plasma is evidently important, but far to be clarified. For example, processes (1) - (4) must be important for plasma diagnostics. Namely, concerning diagnostic methods, based on the analysis of atomic and ionic spectral line shapes, it has been discussed recently (Astapenko, Bureeva and Lisica 1998) the particular importance to study any process not taken into account up to now, influencing even little the ionization degree of a gas plasma. This makes even more important the study of the influence of the chemi - recombination and chemi - ionization processes (1) - (4), on the kinetic inside plasma, since according to their very nature these processes influence most directly the ionization degree of gas plasmas where they occur.

4 Conclusions

Presented results demonstrate clearly that the chemi - recombination and chemi - ionization processes (1) - (4) with $A = H$ and $A = He$ may be of particular interest for astrophysical plasmas. First of all this concerns to modeling of atmospheres of particular hydrogen rich stars (Sun and stars of similar type) and for some helium rich stars (some of DB white dwarfs). Also, our discussion of the results obtained. shows the necessity of the further research of the processes (1) - (4) influence on the real kinetic of non-equilibrium weakly-ionized plasmas, with the emphasis on the excited atomic state populations and the degree of plasma ionization.

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BELDATA - THE DATABASE OF BELGRADE ASTRONOMICAL OBSERVATORY

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Abstract

BELDATA is Internet searchable database contains Stark broadening parameters, spectra of Active Galactic Nuclei, observations from Belgrade Astronomical Observatory and papers and abstract published by Astronomical Observatory in Belgrade. For now on, our main effort is on Stark broadening parameters database. Internet address of BELDATA is: http://www.aob.bg.ac.yu/BELDATA.

database: Stark broadening parameters

1 Introduction

Internet, as a powerful tool, provide fast and easy access to various data. As a part of Internet there is large amount of databases holding specific data for astrophysics and physics community. Our contribution to Internet databases is BELDATA (Belgrade Astronomical Database, Milovanović et al. 2000, Popović et al. 1999). This database will be in four parts:

- Stark broadening parameters,
- Spectra of AGN's,
- Observations made at Belgrade Astronomical Observatory and
- Abstract and papers published in *Serbian Astronomical Journal* and *Publications of the Belgrade Astronomical Observatory.*

As a first step, we installed demo version of BELDATA. It shows how to use this database. This probe version contains only some parts of our Stark broadening parameters calculations.

2 Stark broadening parameters database

In early-type stars, like B and A stars as well as in white dwarfs, Stark broadening is the main pressure broadening mechanism, and the corresponding Stark broadening parameters are of interest for a number of investigations related to stellar opacities, stellar atmosphere modeling and investigations, abundance determinations, interpretation and modeling of stellar spectra and laboratory plasma research.

In a series of papers, large scale calculations of Stark broadening parameters for a number of spectral lines of various emitters performed on Belgrade Observatory have been published. Our calculations have been performed within the semiclassical perturbation formalism (Sahal-Bréchot 1969ab) for transitions when a sufficiently complete set of reliable atomic data exist and within the modified semiempirical approach (Dimitrijević & Konjević 1980, Dimitrijević & Kršljanin 1986) when semiclassical results are of low accuracy due to incomplete set of experimental atomic energy levels data for considered emitters.

To provide our results to scientific community we established BEL-DATA database. This database is directly connected with Internet to enable easy and fast access for world wide users.

User can search core of Stark broadening database filling simple and user friendly query entering emitter name, ionization degree, electron density and transition. As result user will obtain Stark broadening widths and shifts for needed Stark broadening parameters. In the future we will extent query form so that user can for example enter wavelength range in which he want to search database. We have plans to begin cooperation with some other databases with similar data, e.g. VALD - Vienna Atomic Line Database (Kupka et al. 1999).

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Astronomy in Serbia

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Abstract

A review of professional and amateur astronomy in Serbia is given.

1 Belgrade Astronomical Observatory

The principal astronomical institution in Serbia is the Belgrade Astronomical Observatory, one of the oldest scientific organizations and the only autonomous astronomical institute in Yugoslavia. Its past development forms an important part of the history of science and culture in these regions. The decree of its founding conjointly with the Meteorological Observatory was signed on 20 March (7 April) 1887 by the Minister of Education and Church Affaires of Kingdom of Serbia Milan Kujundžić on the initiative of Milan Nedeljković (Belgrade 27. Sept. 1857 - Belgrade 27 Dec. 1950), a professor of the Grand School (Belgrade University). Nedeljković was appointed first director of the newly founded Observatory.

On 1 May 1871 Nedeljković started his activity at the provisory Observatory in the rented Geizler family's house. Here the Observatory was operating until 1 May 1891, when it was moved into its own building constructed meanwhile - the one in which at present is Meteorological Observatory in the Karadjordje Park. In the minor museum section of this building there is, since the celebration of the Observatory's centenary in 1987, a room dedicated to the origins of astronomical science in Yugoslavia.

Nedeljković was at the head of the Observatory from 26 March (7 April) 1887 until 30 January 1924. A break took place only between 5 July 1899 and 31 October 1900, when he was sent into retirement for political reasons, in connection with the Ivanjdan attempt on King Milan, which was exploited by King Alexander for settling accounts with his political opponents. Nedeljković's place was filled during this period by Djordje Stanojević (Negotin, 7 April 1858 - Paris 24 Dec. 1921), the first Serbian astrophysicist, later on the rector of Belgrade University. Dj. Stanojević was a great popularizer of astronomy and science in general; he was the driving force in the introduction of electrical light in Belgrade, Užice, Čačak, Leskovac... He was the builder of the first hydroelectric power station in Serbia, a pioneer of industry of refrigerating appliances, the initiator of setting up a committee for cooling problems and of forming an international organization for cooling technique in Paris in 1903. He was also the pioneer of the color photography in Serbia.

Apart from its importance for astronomy and meteorology, the newly built Observatory, headed by Nedeljković, was a cradle of the seismic and geomagnetic researches in Serbia. Nedeljković borrowed the instruments for geomagnetic measurements from Tege Miklosh Konkoly, the founder of the Budapest Astronomical Observatory, and took care of building an earth-magnetism pavilion. Thanks to Konkoly, Nedeljković acquired in 1903 also a seismograph, installed next year in a special pavilion. The observations were carried out regularly and for these purposes the construction of what at present is the Seismological Institute was executed in 1906. This activity was taken over by Nedeljković's assistant Jelenko Mihailović (Vrbica, 11 Jan. 1869 - Belgrade 10 Oct. 1958) who worked at the Observatory since 1896.

During the Austro-Hungarian occupation of Serbia in World War I, the Observatory was administered by Victor Konrad from Vienna. During their flight from Serbia the Austrians took away or destroyed all the instruments. However, thanks to his extraordinary and professional skill Nedeljković contrived to acquire in Germany after the war, on account of war reparations, a number of instruments appertaining equipment for the new Observatory.

The instruments procured by Nedeljković constitute still practically the only observing basis of the Observatory, although some of them were taken away by the Germans during the World War II, two were ceded to each Ljubljana and Zagreb Universities (Djurković 1968), some of the smaller ones being left unmounted.

Currently mounted in appropriate pavilions are the following instruments procured by Nedeljković:

1. Large Refractor - ZEISS 650/10550mm equatorial;
2. Solar spectrograph (monochromatic) LITTROW, 9000 mm/100.000 developed by adapting to the ZEISS 200/3020 mm equatorial two astro cameras TESSAR and PETZVAL 160/800 mm;
3. Large Transit Instrument ASKANIA 190/2578 mm;
4. Large Vertical Circle ASKANIA 190/2578 mm;
5. Astrograph ZEISS 160/800 mm;
6. Photovisual Refractor ZEISS 135/1000 mm and 125/1000 mm;
7. Transit Instrument BAMBERG 100/1000 mm;
8. Zenith-telescope ASKANIA 110/1287 mm;

Large Meridian Circle ASKANIA 190/2578 mm burnt up on 11th of May 1999 during NATO air attack.

As Nedeljković was struggling for the new Observatory at which the acquired instruments were to be mounted and regular astronomical observations started, he suddenly was sent into retirement on 30 Jan. 1924. By ruling of the Faculty Council the Observatory was divided into two separate institutions: Astronomical Observatory and Meteorological Observatory of Belgrade University.

At the head of the Astronomical Observatory was appointed in 1925 Vojislav V. Mišković (Fužine 18 Jan. 1892 - Belgrade 25 Nov. 1976), at the time already a well established astronomer engaged at Nice Observatory, France. He began his astronomical studies in Budapest and Göttingen before the World War I. On his demobilization at the end of 1918 from the Serbian Army, in which he served as a volunteer, he was sent to France to complete his studies. He graduated in 1919 and was appointed assistant at the Marseille Observatory. Since 1922 he was engaged as an astronomer at the Nice Observatory, receiving his doctor's degree in 1924 at the Montpellier University. In 1925 he won French Academy Prize for his studies in stellar statistics. In the period 1919-1925 he published a score of papers in the French scientific journals, treating the observation of the minor planets and comets and the determination of their orbits. He came to Belgrade in 1926 taking, in addition to the Astronomical Observatory, charge of the newly established Chair of Theoretical and Practical Astronomy at the Faculty of Philosophy, whereat he was elected associated professor. In 1929 he was elected corresponding member of the Serbian Royal Academy and in 1939 its full member. He directed the Observatory's activity to a considerable degree toward mathematical and numerical works, which yielded valuable results. Of importance are numerical works connected with the Mathematical Climatology of M. Milanković as well as with Mišković's own Precession Tables.

In 1929 Mišković succeeded in getting funds for the constructions of a new, modern, observatory, at 6 km distance southeast from the city's centre, occupying a 4.5 ha area at 253 m high hill Veliki Vračar, named since, along with the entire surrounding part of Belgrade, Zvezdara (=concerned with stars).

Exceptional and highly valued complex constituting the Astronomical Observatory was drawn up by Jan Dubovi, a member of GAMP (Group of Modern Outlook Architects) founded in 1928. It is thanks to this very achievement that Dubovi was conferred a doctor of science degree in Prague. The construction works were carried out in 1930 to 1932, the instruments being mounted during the following two years.

Mišković started also publishing the scientific periodical Mémoires de l'Obs. Astr. Belgrade (issued five volumes for: 1932, 1933, 1936, 1938 and 1949), Annuaire de l'Obs. Astr. Belgrade (six volumes for 1929 through 1934) containing sidereal time, short-period nutation terms, the mean and apparent places of 189 stars, newly discovered minor planets and directions for use. Nautički godišnjak (Nautical Almanac) for years 1934 through 1941) for navigation purposes in the Navy and Godišnjak Našeg Neba (Almanac of our Sky) an astronomical calendar in Serbian, issued in the years 1930 to 1941 and 1948 to 1952 (the 1948 issue was edited by F. Dominko and the issues for 1949, 1950 and 1951 by B. Popović.

In 1936 Mišković, assisted by Milorad Protić, organized the Minor Planets and Sun Observation Service. In the same year P. Djurković discovered at the Uccle Observatory, Belgium, a minor planet, subsequently named 1605 Milanković and M. Protić, at the Belgrade Observatory, discovered the minor planet 1564 Serbia, which marked the opening of a long series of 43 minor planets discovered by the Belgrade astronomers. Protić alone, in the period 1936-1956, made 33 discoveries. Of the 43 minor planets owing their discovery to Belgrade astronomers, 12 have obtained by the IAU permanent names, three of the discoveries having later been ascribed to other authors.

Besides Serbia, using his author's right, Protić gave the following names to the minor planets he discovered: 1507 Beograd, 1550 Tito, 1554 Yugoslavia, 1675 Simonida, 1724 Vladimir (after his grandson), 2244 Tesla and 2348 Mišković. P. Djurković discovered in the period 1936-1941, 5 minor planets, one of them - Zvezdara- named by him using his discover's prerogative. In 1980 Z. Knežević discovered on the photo-plates taken according to his instructions at Piszkesteto Observatory, Hungary, four minor planets, one of which having obtained the name 3276 Paolicchi, after one of his colleagues in Italy. In 1991, as a mark of honour, a minor planet was given the name 3900 Knežević - after our fellow. Another minor planet connected with the Belgrade Observatory is that named 1555 Dejan, after P. Djurković's son.

In 1936 Mišković started issuing Bulletin de l'Observatoire astronomique de Belgrade, a scientific periodical which from No. 145 for 1992 on appears under the name Bulletin astronomique de Belgrade, and from the number 157 for 1998 under the name Serbian astronomical Journal. This periodical's editors have been: V. V. Mišković (1936-1940, 1943 – 1948 and 1952-1956), M. Protić (1941-1942, 1955-1960 and 1971-1975), B. Popović (1950), V. Oskanjan (1964), P. Djurković (1964-1970), M. Mijatov (Nos. 127-131 in 1976-1981), D. Zulević (Nos. 132-133, in 1982-1983), Dj. Teleki (Nos. 134-136 in 1984-1986) and M. S. Dimitrijević (No. 137 in 1987 successively up to date).

Since July 1941 at the Observatory were quartered German military. The Wehrmacht brought along profs. Grotrian and Kippenheur from Potsdam, the two having inscribed the Observatory's instruments as German property, dispatching to Germany the spectroheliograph and the comet searcher. On the terraces of the Observaroty's edifice and on the water storage building pillboxes were erected for directing the flak, while the library was turned into officers mess. In the course of the liberation fightings in 1944 particularly heavy damages were inflicted on the main edifice, the water storage building and on "Large Refractor" pavilion. The Observatory's reconstruction was undertaken immediately after the war. Mišković remained its director until March 1946 when he submitted his resignation, accepted not before May 1948.

In 1945 P. Djurković started and edited the professional periodical Astonomska i Meteorološka Saopštenja (Astronomical and Meteorological Reports), published by the Observatory up to 1950 (seven issues in all). In 1947 Observatory started the series Publikacije Astronomske Opservatorije u Beogradu (Publications of Astronomical Observatory). Its editors in chief were: V. Oskanjan (No. 10), P. Djurković (Nos. 12-16), M. Protić (Nos. 17-19, 20-21) Dj. Teleki (Nos. 20, 26, 32, 34 and 35), M. Mijatov (Nos. 24, 25, 27-31), G. Popović (No. 33) and M. S. Dimitrijević (Nos. 36-69).

Up to 1 July the Observatory was, as it was before the war, under the Belgrade University. From that date on, up to 18 Dec. 1950. it is under the jurisdiction of the Serbian Academy of Sciences and thereafter, under the Committee for Scientific Institutions, University and Schools for Higher Education of SR Serbia. This status was kept until 27 March 1954, when the Observatory became institution with independent financing at the Executive Council of SR Serbia. On 9 Aug. 1985 the Observatory obtained the status of autonomous scientific research institute with the Executive Council of the Assembly of SR

Serbia as its founder, its name changed into Astronomical Observatory - Institute for Astronomical Researches. At the time it was financed by the Republic Community of Sciences of SR Serbia. After Community's dissolution it is being financed by the Republic Fund for Science of Serbia through the scientific project "Physics and Motion of Celestial Bodies and Artificial Earth's Satellites" (1985-1990). Leading the Project were: Dj. Teleki (1985-1987), A. Kubičela (1987-1989) and M. Dimitrijević (1990). In the period 1991-1995 the Project is named "Physics and Motion of Celestial Bodies" and was led by M. Dimitrijević (1991-1993) and Z. Knežević (1993-1996). For the period 1996-2000 the project is named "Astronomical, Astrodynamical and Astrophysical Researches", being led by Z. Knežević. The Time and Latitude Services are financed directly from the budget of SR Serbia. On 12 May 1992 the Observatory became a scientific institute financed through the mentioned scientific project at the Republic Ministry for Science and Technology, its founder being the Government of Republic Serbia. On 20 Dec. 1994 the Observatory was re-registrated as a scientific institute, resuming its old name.

When in May 1948 V. Mišković's resignation was accepted, to the post of Observatory's director was appointed academician Milutin Milanković (Dalj 28 May 1879 - Belgrade 12 Dec. 1958) who went down in history of science by his having explained the ice ages phenomenon through the slow changes in the Earth's insolation in consequence of the Earth's axis inclination and its motion around Sun, undergoing changes produced by various influences. Milanković elucidated also the history of the climate of Earth and other planets, being the originator of the mathematical theory of the Earth's poles motion. The Observatory's direction was entrusted to the Observatory's Council, at the head of which was the director and Council's president M. Milanković, with members Anton Bilimović, V. Mišković and Pavle Savić (Popović 1951). Milanković held this post till 26 June 1951.

In 1951 P. Djurković organized the Double Star Service. Within this Service, subsequently named Group, were discovered over 200 new double and multiple stars, the bulk of the which is due to Georgije Popović, working in this Group since 1960, being at its head since 1976.

In this same year the Variable Stars Service was organized by Vasilije Oskanjan. In this he was joined by Alexander Kubičela and Jelisaveta Arsenijević (at the Obsevatory since 1956) whereby an impetuous development of the astrophysical researches took place later directed toward stellar and solar physics and astronomical spectroscopy. Initially it was the photometry of eruptive stars which was pursued. Since 1959, after Oskanjan's return from his specialization in the Soviet Union, it was the work in the field of polarimetry of eruptive stars that was taken up. Formally, the Astrophysical Group was founded in 1960. In 1969 and 1970 working in the Group was Trajče Angelov. In 1972 the Group was joined by Ištvan Vince, in 1980 by Gojko Djurašević, in 1983 by Slobodan Jankov, in 1984 by Milan Dimitrijević, in 1985 - 1996 by Vladimir Kršljanin, in 1989-1996 by Olga Atanacković-Vukmanović (at the Observatory since 1982 first in the Absolute Declinations Group), in 1991 by Sanja Erkapić and Snežana Marković, in 1992 by Luka Popović, in 1994 by Darko Jevremović and in 1995 by Silvana Nikolic. Since 15 February 1997 the Group was joined by Milan Ćirković, since 1st January of 1998 by Dragana Tankosić and Nataša Trajković (since 14 November 1998 Nataša Stanić), since 15 April 1998 up to 1 November 1999 by Desanka Šulić, since 1 January 1999 by Edi Bon, since 20 January 1999 by Nenad Milovanović and since 1 December 1999 by Oliver Vince.

From 26 June 1951 to March 1954 the Observatory's director is again V. Mišković. After he went into retirement the Observatory was headed by M. Protić in the capacity of deputy director and from 21 Nov. 1956 to 21 Nov. 1960 as a director.

After M. Protić at the head of the Observatory was Vasilije Oskanjan, first as acting director since 1960, then in 1964-1965 as the director. Following him, from July 1965 to 1970, the director was Pero Djurković. After him in the period 1971-1975 at the head of Observatory is again M. Protić. Since 1975, first as acting director and from 13 July 1977 to Sept 1981 as the director was M. Mijatov (Belgrade 3 July 1933 - Belgrade 19 Nov 1996). The director's post from 1982 to 1989 was held by Miodrag Mitrović, in 1990-1993 by Ištvan Vince and from 21 Nov 1994 on, by Milan Dimitrijević.

In 1986, on the part of the Assembly of SR Serbia and Republic Executive Council, the project was adopted and funds allocated for the building of an astrophysical observing station at Rgaj mountain near Prokuplje. Due to the investments in the Republic having meanwhile been suspended, the project has not been realized yet.

In 1987, in the presence of a number of statesmen and eminent guests from the country and abroad, the centenary of the Observatory's founding was solemnly celebrated in the hall of the Assembly of Serbia. On the occasion of this jubilee three international and one Yugoslav scientific conferences were held: IAU Colloquium 100 "Fundamental Astrometry" (8-11 Nov. - Chairman SOC H. Eichorn, Gainsville, USA), International Symposium on Astronomical Refraction in memory of Dj. Teleki, former President of IAU Working Group on Astronomical Refraction (3-4 Nov., Chairman SOC V. Milovanović), Second International Symposium on Catastrophic Collisions of the Small Sollar System Bodies (8-11 Nov., Chairman SOC V. Zappala, Italy) and Second Workshop "Astrophysics in Yugoslavia" (8-10 Nov Chairman SOC M. Dimitrijević). During these festivities a minor museum was opened in the old Observatory's building in Karadjordje Park, one of its rooms being dedicated to the development of the Astronomical Observatory.

In 1994 there took place a reorganization of the Observatory's inner structure, resulting in the establishment of : Department of Astrophysics, Department of Dynamical Astronomy and Department of Astrometry. Since 15 February 1997, Department of Astrometry was joined by Nataša Popović and since 20 May 1998 by Predrag Jovanović (working since 1 January 1996 in Time keeping and geographic coordinates determination service).

In 1995 the Observatory participated in the organization of the International Russian - Yugoslav Conference "Newcomb and Fundamental Astrometry" in St. Petersburg, of the First Hungarian-Yugoslav Conference in Baja and the First Romanian-Yugoslav Round Table on collaboration in astronomy in Temishoara; it organized the First Yugoslav Conference on Spectral Line Shapes in Krivaja.

In 1996 the Observatory organized the Second Yugoslav-Romanian Round Table on collaboration in astronomy in Belgrade and the Astrophysics Section at the 18th Summer School and International Symposium on the Physics and Ionized Gases in Kotor. The Observatory participated in the organization of the First Belaruss-Yugoslav Conference on Physics and Dynamics of Laboratory and Astrophysical Plasma in Minsk. The Observatory's fellows presented their results at 13 international and 6 national conferences. They published 129 bibliographic items of which 16 in the international leading journals. It published 4 volumes of Publ. Astron. Obs. Belgrade and 2 Nos. of its periodical Bull. Aston. Belgrade.

In 1997 the Observatory organized in the framework of celebration of its 110th anniversary the scientific conference "Development of Astronomy among Serbs". It took part also in the organization of the Third Romanian-Yugoslav Round Table on Cooperation in Astronomy in Kluj-Napoca, as well as in the Second Yugoslav Conference on Spectral Line Shapes in Bela Crkva. It fellows presented their results at 13 international and 4 national conferences. They published 152 bibliographic items, 11 of which in international journals of the highest standing.

During 1998, 154 bibliographic items have been published, with 19 among them in international scientific journals of the highest standing. Five invited lectures and progress reports have been given by fellows of Observatory at international conferences and one at national one. Four reviews and monographic texts in national publications have been published. Observatory's fellows have participated in works of 16 Scientific conferences abroad (28 participations by 19 fellows) and six conferences in Yugoslavia (61 participation by 28 fellows). Organized by the Observatory were IV Yugoslav - Romanian Astronomical Meeting, Belgrade, 5-8.05.1998; I Bulgarian - Serbian Astronomical Seminar, Belogradchik, 6-7.08 1998 and II Yugoslav - Belarussian Symposium on Physics and Diagnostics of Laboratory and Astrophysical Plasmas, Zlatibor, 5-6.09.1998. It issued four publications of the series Publ. Astron. Obs. Belgrade and two Nos. of its periodical Bull. Astron. Belgrade. As from 1998 Astronomical Observatory has an internet connection available from each personal computer on Observatory with Windows 95 installed.

During 1999, in spite of NATO air attacks on Yugoslavia and the destruction of the Big meridian circle, 112 bibliographic items have been published, 23 among them in international scientific journals of the highest standing. Six invited lectures have been given by Observatory's fellows at international conferences and five at national ones. Moreover, two Ph. D and one M. Sc Thesis have been published. Numbers 159 and 160 of the Observatory's publication Serbian Astronomical Journal, as well as Nos. 63, 64, 65 and 66 of the Publications of the Astronomical Observatory of Belgrade have been issued. These publications are regularly sent to 136 institutions and libraries in 45 countries and to 15 institutions and libraries within Yugoslavia. Observatory's fellows have participated in works of 8 scientific conferences abroad (9 participations by 6 fellows) and three conferences in Yugoslavia (35 participation by 22 fellows).

During 1999, Belgrade observatory organized or took part in the organization of the following conferences: III Yugoslav Conference on Spectral Line Shapes, Brankovac (Fruška gora), 4-6.10.1999; XII National Conference of Yugoslav Astronomers and International Workshop on the Development of Astronomical Databases, Belgrade, 19-21.11. 1999 and Symposium Milanković - juče, danas, sutra (Symposium Milanković - yesterday, today, tomorrow), Belgrade, 25-26.11. 1999.

Besides numerous newspaper articles and radio and TV emissions Observatory's fellows authored, explaining particularly the 11th August 1999 total Solar eclipse, they gave 48 lectures on astronomical subjects outside our institution contributing to the cultural life in our country. Moreover 4 lectures have been given at the Astronomical Observatory itself.

I note as well that Serbian Astronomical Journal is available on www through the Astrophysical Data System (ADS), thanks to the courtesy of the System's holders. The www address is: http://adswww.harvard.edu.BOBeo. During 1999, the web site of the Belgrade astronomical observatory has been made and the corresponding www address is: http://www.aob.bg.ac.yu. Moreover the database BELDATA has started to develop and it is available through internet with the address: http://www.aob.bg.ac.yu/BELDATA.

Currently there are 40 employees at the Observatory 32 of them are astronomers.

In the course of its history the Belgrade Astronomical Observatory grew to an institution of great importance in the history of science and culture of the Serbian people, not only in the field of astronomy but also in meteorology, seismology and geomagnetics. Linked to this institution are the names of the famous personalities in the history of science who contributed to the Observatory, and the scientific achievements of Serbian astronomers in general, having earned esteem in the international scientific community as well as to the young having a good perspective, in our country too, in engaging in this beautiful and challenging science, in an ambience enabling them to achieve results of the highest value.

2 University teaching of astronomy in Serbia after the Second world war

Beside Astronomical Observatory, there is in Belgrade also the Chair of Astronomy at the Faculty of Mathematics. As the Faculty of Sciences separated from the Philosophical Faculty in 1947, the Chair of Celestial Mechanics and Astronomy was formed, having shortly thereafter changed its name into Chair of Mechanics and Astronomy. The splitting up of this Chair into the Chair of Mechanics and the Chair of Astronomy began in 1960, being completed in 1962. The reorganization of the Faculty of Sciences in 1971 entailed the Chair of Astronomy becoming the Institute of Astronomy. In 1995 there took place the division of the Faculty of Sciences into several faculties. As the Faculty of Mathematics there remained the Chair of Astronomy which re-took, in the new organization, its old name.

In 1961 two study groups were formed - one for Astronomy, the other for

Astrophysics. Currently, there are at the Chair of Astronomy 12 full time astronomers and one engaged at one third-time basis, teaching fifteen subjects. The names of the Chair's fellows, the subjects they are lecturing on, as well as their electronic addresses are given in Appendix.

Beside Belgrade, Astronomy is taught at University in Novi Sad, Niš and Kragujevac. At the Faculty of Sciences of the Novi Sad University there is, since 1986, in 8th semester, the subject "Astrophysics and Astronomy", involving twice a week lectures and twice a week exercises. The subject is obligatory for students wishing to teach Physics in the secondary schools while being optional for students of Applied Physics.

At the Faculty of Philosophy of the Niš University in the study group for Physics, within the specialized training in General Physics, since the school year 1990/91 until 1993/94 there was taught twice a week in the 7th and 8th semesters, the subject Fundamentals of Astrophysics. The subject was thereafter dropped for two years from the curriculum, to be again taught within the 7th semester twice a week. In addition, there is in the study group for chemistry a Chair for Geo- and Cosmochemistry, occupying itself with the study of meteors and meteorites.

At the Faculty of Sciences of the Kragujevac University there has been introduced in the school year 1998/99 the subject Astrophysics and Astronomy in the 6th semester of the specialized training of the Group for Physics, with twice a week teaching and twice a week exercises.

3 Amateur astronomical societies

In addition to professional Astronomy, well developed in Serbia is also the amateur Astronomy. The largest and the oldest organization of amateur-astronomers is the Astronomical Society "Rudjer Bošković" in Belgrade (Kalemegdan, Gornji Grad 16, 11000 Belgrade), which in the course of 65 years of its existence was spreading astronomical knowledge in our country. The founding meeting was held on 22 April 1934. The first Society's President was Djordje Nikolić (1934-1936) and the second Vojin Djuričić (1936-1941), the governor of the State Mortgage Bank.

After the War, on 9 December 1951 was held the founding meeting of the Belgrade Astronomical Club "Rudjer Bošković" (as component part of the Association of students of the Natural-Mathematical Faculty (PMF)), Dr Radovan Danić being elect its President. Considering that already in 1952 there were in the Club 64 members, the majority of whom were not associated with the PMF, the Club Administrative Committee took decision on 23 March 1952, the Club to be re-registered into Astronomical Society "Rudjer Bošković". The founding meeting of the Society was held on 18 May 1952, Radovan Danić having been elected its President (1952-1966). Following him the Society' Presidents have been: Branislav Ševarlić (1966-1970), Pero Djurković (1970-1972), Nenad Janković (1972-1974), Božidar Popović (1974-1979), Zoran Knežević (1979-1982) and Milan S. Dimitrijević (1982-).

In 1953 the Society, jointly with the Aeronautical Association of Yugoslavia, started publishing the periodical for astronomy and aeronautics (currently for astronomy) "Vasiona" (Universe). The periodical's editors in chief were: Nenad Dj. Janković (1953-1972), Pero Djurković (1973-1974), Jelena Milogradov-Turin (1975-1982), Branislav Ševarlić (1983-1984) and Milan S. Dimitrijević (1985-).

Thanks to the exertion of Pero Djurković and Radovan Danić with the authorities concerned, the Society obtained for itself the permises? in the Despot Tower at Kalemegdan where, on 20 December 1964 was solemnly opened the People's Observatory, whose regular activity started in June 1965. The Society managed also to procure a Zeiss planetarium, which was installed in an old spacious steam bath-house - Turkish Hamam - in the Kalemegdan Donji Grad. The Planetarium started operating in 1969, being formally opened on 17 February 1970.

The founding meeting of the Astronomical Society "Novi Sad", ADNOS (Jaroslav Francisti, Astronomska Opservatorija, Petrovaradinska tvrdjava, 21000 Novi Sad), took place on 4 March 1974. In 1976 the Society bought telescopes 20T Observatory 108/1600 mm and 10K 80/1200 mm and 14T 60/900 mm, of the American firm TASCO, and in 1991 purchased the reflector type telescopes Meade 200/1500 mm and 102/1000 mm. In 1989 the adaptation of the Astronomical Observatory at the Petrovaradin Fortress was completed while in 1996 the premises for the planetarium were secured and its adaptation is now finished. The Society's President in the period 1974-1980 was Živojin Ćulum, in the period 1980-1984 Božidar Jovanović, 1984-1998 Djura Paunić, from 1998 - up to 1 September 2000 Svetislav Krstić, and from 1 September 2000 the President is Dragoslav Petrović.

At Petnica near Valjevo the organization of the Young Researchers of Serbia is building the House of Young Researchers. This institution, initially of a recreative character, became the Research Station Petnica (Istraživačka stanica Petnica, Petnica, 14000 Valjevo). The first programmes were carried out in 1982, the first seminar in Astronomy in 1983 in preparation for going out for Rgaj Mountain, where astroclimatic explorations were conducted. In 1968 was obtained a Celestron telescope of Schmidt-Cassegrain type, objective diameter 20 cm. Later on were purchased Celestron, opening 102 cm, as well as a reflector of 33 cm opening, manufactured by Aljoša Jovanović. The heads of the seminar were Darko Jevremović, Silvana Nikolić, Samir Salim and Nikola Božinović, the duty being currently discharged by Oliver Vince.

In Valjevo, within the framework of the Society of researchers "Vladimir Mandić - Manda", founded on 16 February 1969, there is active also the Astronomical Group founded in 1972 (Nikola Božić, Birčaninova 68, p. fah 118, 14000 Valjevo).

In Kragujevac, on the roof of the Institute of Physics of the Faculty of Sciences, there is the Belerofont Observatory (Vukota Babović, Institut za fiziku PMF, Sestre Janjić 4, Kragujevac), opened on 20 February 1986. It disposes of a telescope Meniscus Cassegrain Spiegel 130/2250 mm.

In Niš, at the close of the sixties and the start of the seventies, there was operating a branch of the Astronomical Society "Rudjer Bošković, while at the Faculty of Philosophy there existed in the period 1876-1980 the "Astro-

Geophysical Society". In the year 1996 there was founded Astronomical Society "Alpha" (Dragan Ž. Gajić, Filozofski fakultet, Studijska grupa za Fiziku, p. fah 91, 18001 Niš). The first Society's President was Zoran Sekulić, while from March 1997 on, the President is Dragan Ž. Gajić.

In 1996 Zrenjanin too got an organization of amateur astronomers, Astronomical Society "Milutin Milanković" (Miša Bradić, Zrenjaninska gimnazija, Gimnazijska 2, 23000 Zrenjanin).

The amateur astronomers societies greatly contributed to the spreading of astronomical knowledge in our midst and to keeping step with the latest astronomical achievements and discoveries, the creating a more suitable climate for the development of Astronomy in Serbia.

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Бања Лука

Како разумјети Универзум: допринос астрономских и физичких истраживања

29.мај 2009,
Република Српска, БиХ

Како разумјети Универзум: допринос астрономских и физичких истраживања

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Судари емитера и апсорбера са наелектрисаним честицама и звездана плазма

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Сажетак. Судари емитера и апсорбера са наелектрисаним честицама, утичу на профиле спектралних линија звездане плазме, пошто услед цепања и померања енергетских нивоа атома у електричном пољу (Штарков ефекат) долази до ширења и померања линија у спектрима. У раду је анализирана важност Штарковог ширења оваквих линија за анализу, интерпретацију и синтезу звезданих спектара, анализу, дијагностику и моделирање звездане плазме и значај оваквих резултата за истраживања лабораторијске, фузионе и технолошких плазми као и за физику ласера. Размотрено је код каквих типова звезда и при којим истраживањима је Штарково ширење значајно и дискутовани су методи за теоријско одређивање параметара ширења спектралних линија, као и могућности, које пружају регуларности и систематски трендови, за критичку процену оваквих података нађених у литератури и интерполацију непознатих потребних података на основу постојећих. Такође је дат и преглед оваквих истраживања на Астрономској опсерваторији у Београду.

Програм рада

28. 05. 2009.

Пријем учесника Конференције

29. 05. 2009

9.00-9.20 **Свечано отварање**

Предавања по позиву

09.20-10.00

Лука Поповић, ПМФ Бања Лука и Астрономска опсерваторија Београд
Савремена истраживања у астрофизици: Од открића телескопа до данас,

10.00-10.40

Милан Димитријевић, Астрономска опсерваторија Београд
Судари емитера и апсорбера са наелектрисаним честицама и звездана плазма,

10.40-11.20

Бранко Драговић, ПМФ Бања Лука и Институт за физику Земун
Тамна страна васионе

11.20-13.00 **пауза за ручак**

13.00-13.40

Дарко Јевремовић, Астрономска опсерваторија Београд **Моделирање звезданих атмосфера,**

13.40-14.20

Драгана Илић, Математички факултет Београд
Активна галактичка језгра: природа и физика објеката

14.20-15.00

Синиша Игњатовић, ПМФ Бања Лука
Космогонија Сунчевог система

15.00-15.20 **пауза**

15.20-15.40 **Мухамед Муминовић,** DVD презентација службеног материјала IYA2009 „Очи уперене у небо" преведеног на наш језик.

15.40-16.20 **Презентација постера**

16.20-17.20 **Округли сто**

30. 05. 2009 Испраћај учесника скупа

УНИВЕРЗИТЕТ У БАЊОЈ ЛУЦИ
Природно-математички факултет
Бања Лука

Научно-стручни скуп

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- зборник радова -

28.-29. мај, Бања Лука,
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Спонзор:
Министарство науке и технологије
Републике Српске

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САДРЖАЈ

Судари емитера и апсорбера са наелектрисаним честицама и звездана плазма

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Сажетак. Судари емитера и апсорбера са наелектрисаним честицама, утичу на профиле спектралних линија звездане плазме, пошто услед цепања и померања енергетских нивоа атома у електричном пољу (Штарков ефекат) долази до ширења и померања линија у спектрима. У раду је анализирана важност Штарковог ширења овакvих линија за анализу, интерпретацију и синтезу звезданих спектара, анализу, дијагностику и моделирање звездане плазме и значај оваквих резултата за истраживања лабораторијске, фузионе и технолошких плазми као и за физику ласера. Размотрено је код каквих типова звезда и при којим истраживањима је Штарково ширење значајно и дискутовани су методи за теоријско одређивање параметара ширења спектралних линија. Такође је дат и преглед оваквих истраживања на Астрономској опсерваторији у Београду.

Кључне речи: Штарково ширење, профили линија, звездане атмосфере, бели патуљци, радио рекомбинационе линије, неутронске звезде, атомски подаци, базе података
PACS: 32.60.+j, 32.70.Jz, 52.20.Fs, 95.80.+p, 97.20.-w, 97.60.-s

1. УВОД

Спектрална линија није никада монохроматска. Увек је проширена због неколико разлога. Хајзенбергова релација неодређености показује да не можемо апсолутно тачно познавати координату и импулс честице. Може се показати (види нпр. [1]) да се ова релација може тако трансформисати да повезује ширину енергетског нивоа у атому и време живота електрона у таквом енергетском стању, односно што је време живота електрона краће то је енергетски ниво шири. Пошто је само у основном стању време живота електрона толико дуго да можемо да кажемо да његова ширина тежи нули, све спектралне линије имају неку ширину због ширине енергетских нивоа прелаза којим су настале. Таква ширина се назива природна и не зависи од температуре и густине честица (притиска) већ само од унутрашњих особина атома или јона који зрачи.

Осим овог узрока, линије могу бити проширене и услед Доплеровог ефекта. Пошто се емитери крећу хаотично, сваки емитовани фотон ће имати неки црвени или плави помак у зависности од компоненте брзине у правцу посматрача. Када се ови помаци саберу добиће се проширена спектрална линија. Профил доплеровски проширене линије је Гаусов, пошто је то расподела која описује случајне процесе или догађаје и овај механизам ширења зависи од температуре емитера.

Судари такође доводе до ширења спектралних линија и овакви механизми ширења зависе од концентрације честица које пертурбују емитујући/апсорбујући атом или јон, односно притиска, па се једним именом зову ширење притиском. То су Штарково ширење услед судара са наелектрисаним честицама, Ван дер Валсово ширење или ширење сударима са неутралним атомима и резонантно ширење (види нпр. [1]).

Занимљиво је колико података о звездама можемо сазнати анализом њиховог спектра. Анализом спектралних линија можемо одредити температуру звездане плазме, односно појединих слојева звездане атмосфере, њен хемијски састав и површинску гравитацију. Можемо боље разумети нуклеарне процесе у њеној унутрашњости, и одредити њен спектрални тип и ефективну температуру упоређивањем спектра звезде са стандардним спектрима за поједине типове.

Истраживање Штарковог ширења је развијена научна област у Србији и бившој Југославији, која има критичну масу научника, и захваљујући и свом мултидисциплинарном значају пружа добру основу за успешну сарадњу. Аутор је публиковао преглед истраживања облика спектралних линија у Србији и Југославији са библиографијом и индексом цитата за период од првог рада објављеног 1962. до краја 2000. године [2-6]. У том периоду је регистровано 1427 (1222 од српских аутора) библиографских јединица које је објавило 179 југословенских аутора (152 из Србије, 26 из Хрватске и један Македонац који живи у Француској). Већина ових радова односи се на Штарково ширење.

У овом раду размотриће се значај Штарковог ширења за истраживања астрофизичке плазме и рад у овој научној области на Астрономској опсерваторији у Београду у Групи за Астрофизичку спектроскопију.

2. УСЛОВИ У АСТРОФИЗИЧКОЈ ПЛАЗМИ И ШТАРКОВО ШИРЕЊЕ

Хенри Расел је 1926. објавио у Астрофизичком журналу чланак [7] са анализом спектра Fe II у коме је пронашао 61 енергетски ниво на основу 214 спектралних линија јонизованог гвожђа. У њему је написао да су сада „све линије од астрофизичког значаја класификоване“. Ипак, 1988. је у чланку Јохансона [8], изјављено да сада познајемо 675 енергетских нивоа Fe II, али да је 50% појединачних спектралних облика у астрофизичким спектрима високе резолуције, још некласификовано.

То је последица чињенице, да су услови у астрофизичким плазмама невероватно разноврсни у поређењу са изворима лабораторијске плазме. Сходно томе, ширење спектралних линија услед интеракције између емитера/апсорбера и наелектрисаних честица (Штарково ширење) у астрофизици је од интереса у плазмама у тако екстремним условима као што су они у међузвезданим облацима молекуларног водоника или у атмосферама неутронских звезда, какви се не могу добити у лабораторијама.

Типичне електронске температуре у међузвезданим молекуларним облацима су око 30 K или мање, а типичне електронске густине су 2-15 cm^{-3}. У таквим условима, јон може да захвати слободне електроне (рекомбинација) у веома удаљену орбиту са главним квантним бројем (n) чија је вредност неколико стотина, па и већа од хиљаду и да се каскадно деексцитује на енергетске нивое n-1, n-2,... зрачећи у радио домену. Такви удаљени електрони су слабо повезани са језгром и на њих могу утицати веома слаба електрична микропоља. Сходно томе, Штарково ширење може бити значајно (види нпр. [9]).

У међузвезданим облацима јонизованог водоника, електронске температуре су око 10 000 K, а електронске густине реда 10^4 cm^{-3} [10]. На одговарајуће серије блиских радио рекомбинационих линија које потичу са енергетских нивоа са великим вредностима n (неколико стотина па и веће од хиљаду) утиче Штарково ширење [10].

За $T_{eff} > 10^4$ K, водоник, главни конституент звезданих атмосфера је углавном јонизован, и међу сударним механизмима ширења спектралних линија, доминантан је Штарков ефекат. То је случај за беле патуљке и вреле звезде О, В и А типа. Чак и у атмосферама хладнијих звезда, као што је Сунце, Штарково ширење може бити значајно. На пример утицај Штарковог ширења у спектралним серијама расте са порастом главног квантног броја горњег нивоа [11-13] и за линије са већом вредношћу овог квантног броја допринос Штарковог ширења је значајан и у Сунчевом спектру [14-16].

На пример спектралне линије - високи чланови Балмерове серије могу се употребити као моћно дијагностичко средство за проучавање звезданих атмосфера. У раду Фелдмана и Дошека [17], употребљени су профили чланова Балмерове серије са главним квантним бројем n између 16 и 32 (на које значајно утиче Штарков ефекат), да би се одредила електронска густина и температура изнад активне области на Сунцу. Опсег густина (у cm^{-3}) и температура (у K) од значаја за радијативне омотаче А и F звезда је 10^{14} cm^{-3} $\leq N_e \leq 10^{16}$ cm^{-3}; 10^4 K $\leq T \leq$ 4x10^5 K [18].

Бели патуљци DA и DB типа имају ефективне температуре између око 10 000 K и 30 000 K тако да је Штарково ширење од значаја за интерпретацију и синтезу њихових спектара и за истраживање, моделирање и анализу њихових атмосфера. Спектри патуљака DA типа карактеришу се широким водониковим линијама (нпр. [19]), а код DB типа у спектру доминирају линије неутралног хелијума. Занимљиво је да је у спектрима белих патуљака откривено Земаново ширење, кога нема у лабораторијским спектрима [20]. Бели патуљци DO типа имају ефективне температуре од приближно 45000 K до око 120 000 K [21] и за истраживање плазме њихових атмосфера Штарково ширење може да буде веома значајно [22].

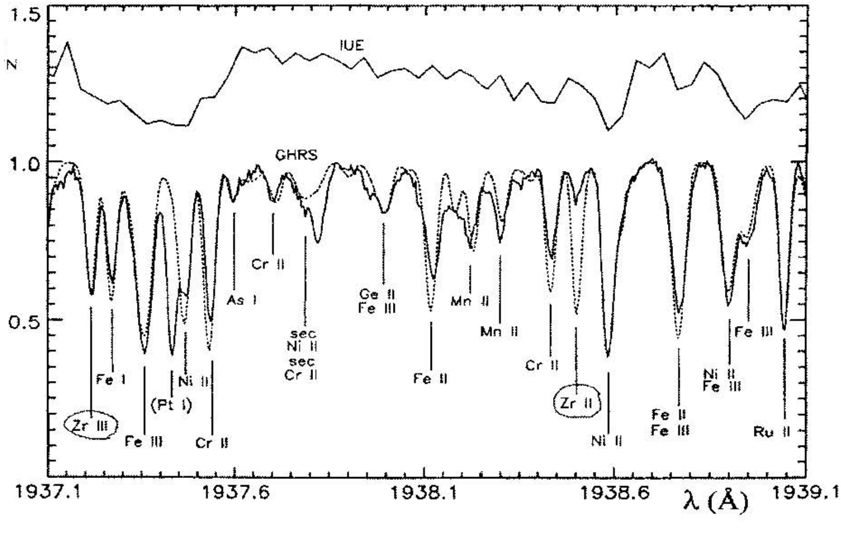
Међу најтоплије звезде спадају оне типа PG1159, врели пре-бели патуљци са мањком водоника, чија ефективна температура се налази у опсегу од T_{eff} = 100 000 K (нпр. за PG1424+535 и PG1707+427) до T_{eff} = 140 000 K (за PG1159-035 и PG1520+525), где је свакако Штарково ширење изузетно важно [23]. Ове звезде имају велику површинску гравитацију (log g = 7), и у њиховим фотосферама доминира хелијум и угљеник са знатним додатком кисеоника (C/He = 0.5 и O/He = 0.13) [23]. У њиховим спектрима, на које јако утиче Штарково ширење, доминирају линије He II, C IV, O VI и N V.

У атмосферама неутронских звезда, густина материје, електронска концентрација и температура су за редове величине већи него у атмосферама белих патуљака, и типичне су за унутрашњост звезда. Температуре на којима се одвија емисија из фотосфере су реда 10^6 - 10^7

K, а електронске густине реда 10^{24} cm^{-3} [24,25]. У реф. [25], финални профил за хелијуму сличну резонантну линију гвожђа је описан помоћу Фогтовог профила, са укупним параметром пригушења једнаким суми природног и Штарковог (судари са електронима) ширења.

3. ПОТРЕБЕ У АСТРОФИЗИЦИ ЗА ВЕЛИКИМ СКУПОМ ПОДАТАКА О ШТАРКОВОМ ШИРЕЊУ

Јасно је да звездана спектроскопија зависи од веома великог броја прелаза за различите атоме и јоне са подацима о њиховим атомским параметрима и Штарковом ширењу што је посебно стимулисано развојем космичке астрономије, пошто је помоћу инструмената као што је Годаров спектрограф велике резолуције (Goddard High Resolution Spectrograph - GHRS) на Хабловом космичком телескопу (Hubble Space Telescope), прикупљен велики скуп спектроскопских података високог квалитета, који стално расте, стимулишући истраживања спектралних линија. То се може лепо илустровати упоређивањем ултра љубичастих спектара χ Lupi добијених помоћу уређаја на сателиту IUE (International Ultraviolet Explorer) и GHRS (сл. 1). Треба узети у обзир да је на сл. 1 приказан део спектра широк само 2 ангстрема и упоредити квалитет посматраних профила спектралних линија.



СЛИКА 1. *УВ спектар звезде χ Lupi добијен помоћу GHRS и помоћу IUE сателита [26]. Резолуција GHRS спектра је 0.0023 nm а максимални однос сигнал/шум је 95 [27]. На GHRS спектру пуном линијом је означен посматран а тачкастом синтетизовани.*

Развој компјутера такође стимулише потребу за великом количином атомских и спектроскопских података. Нарочито велики број података је потребан на пример за прорачун непрозрачности звезданих атмосфера. Илустративан пример може бити чланак о прорачуну непрозрачности за класичан модел цефеида [28], где је у обзир било узето 11 996 532 спектралних линија. Други добар пример колико је велики скуп атомских и спектроскопских података неопходан, је моделирање звезданих атмосфера. На пример компјутерски програм PHOENIX (види [29] и референце у чланку) за моделирање звезданих атмосфера, укључује базу података која садржи податке о $4.2x10^7$ атомских, јонских и молекуларних прелаза.

Занимљива истраживања, која показују могућности које се отварају са развојем компјутерских технологија, и указују потребу за што је могуће већим скупом спектроскопских и атомских података, су прорачуни промена еквивалентних ширина са временом у звезданим јатима и галаксијама, „породилиштима“ (starburst) звезда [30]. У овим истраживањима, рачуната је промена еквивалентних ширина појединих водоникових и хелијумових линија у току 500 милиона година, и поређена са посматрањима звезданих јата и галаксија „породилишта“ звезда. Прорачуни су изведени у два корака. Прво су израчунате популације звезда различитих спектралних типова у функцији времена, а онда су профили спектралних линија синтетизовани додајући различите доприносе појединих спектралних типова звезда. Приликом синтезе профила спектралних линија, узети су у обзир природно, термално Доплерово, Штарково, и ширење линија услед судара са неутралним атомима.

За прорачун преноса зрачења кроз звездану плазму, нарочито у субфотосферским слојевима, као и за одређивање хемијске обилности елемената помоћу апсорпционих линија, потребан је што је могуће потпунији скуп података за што је могуће већи број спектралних линија различитих емитера односно апсорбера, пошто ми не знамо унапред хемијски састав проучаване звезде.

4. ИСТРАЖИВАЊА ЗВЕЗДАНЕ ПЛАЗМЕ

Профили спектралних линија улазе у моделирање слојева звездане атмосфере у оквиру процене величина као што су коефицијент апсорпције κ_ν, Роселандова оптичка дубина τ_{Ross} и укупни пресек за непрозрачност по атому σ_ν. Узмимо да је правац деловања гравитације у звезданој атмосфери z-оса. Ако је атмосфера у макроскопској механичкој равнотежи, а са ρ означимо густину гаса, оптичка дубина је

$$\tau_\nu = \int_z^\infty \kappa_\nu \rho \, \mathrm{dz}$$

$$\kappa_\nu = N(A,\ i)\phi_\nu \frac{\pi e^2}{mc} f_{ij},$$

κ_ν је коефицијент апсорпције на фреквенцији ν, $N(A,i)$ је запреминска густина емитера у стању i, f_{ij} је јачина осцилатора у апсорпцији, m је маса електрона и ϕ_ν профил спектралне линије.

Пресек укупне непрозрачности по атому је

$$\sigma_\nu(op) = M\kappa_\nu,$$

где је M средња маса атома, а непрозрачност по јединици дужине је

$$\rho\kappa_\nu = N\sigma_\nu(op),$$

Уведимо као независну промењљиву средњу оптичку дубину

$$\tau_{Ross} = \int_z^\infty \kappa_{Ross} \rho \, \mathrm{dz}.$$

За Роселандову средњу оптичку дубину τ_{Ross}, κ_{Ross} је дефинисано као

$$\frac{1}{\kappa_{Ross}} \int_0^\infty \frac{\mathrm{d}B_\nu}{\mathrm{d}T} \mathrm{d}\nu = \int_0^\infty \frac{1}{\kappa_\nu} \frac{\mathrm{d}B_\nu}{\mathrm{d}T} \mathrm{d}\nu,$$

$$B_\nu(T) = \frac{2h\nu^3}{c^2}(e^{h\nu/kT} - 1)^{-1}.$$

Сада је Роселандов средњи пресек непрозрачности

$$\sigma_{Ross} = M\kappa_{Ross},$$

Параметри Штарковог ширења су такође потребни за одређивање хемијског састава звезданих атмосфера, односно за одређивање звездане обилности хемијских елемената. Метод који користи синтетичке и посматране спектре и подешавање параметара модела атмосфере да би се добило најбоље слагање, добро је развијен и примењиван на много звезда. Нађено је да постоје хемијски нерегуларне звезде, посебно у интервалу спектралних класа F0-B2 [31], код којих се обилности појединих елемената разликују за неколико редова величине од Сунчевих. Такође је пронађено да је површина CP звезда хемијски нехомогена, тако да је уведен локални хемијски састав, који зависи од координата на звезданој површини [31,32]. Такве неправилности се углавном објашњавају дифузионим механизмом, који делује у звезданим омотачима и (или) атмосферама, као и разликама у радијативном убрзању појединих елемената [33]. Радијативно убрзање g_r на ν, у интервалу фреквенција $d\nu$, које делује на елемент A (чија је густина $N(A)$, а маса m_A је [34]

$$m_A g_r = \frac{\kappa_\nu(A)}{N(A)} \Phi_\nu \frac{\mathrm{d}T}{c},$$

где је $\kappa_\nu(A)$ допринос A монохроматском коефицијенту апсорпције, а Φ_ν флукс зрачења. У непрозрачном омотачу радијуса r, флукс зрачења је приближно једнак [34]

$$\Phi_\nu = \frac{4\pi}{3}\frac{1}{\rho\kappa_\nu}\frac{\partial B_\nu}{\partial T}\left(\frac{-\partial T}{\partial r}\right),$$

$$\kappa_\nu = \kappa_\nu(A) + \kappa_{rest},$$

где су са κ_{rest} означени остали доприноси укупном коефицијенту апсорпције, поред $\kappa_\nu(A)$. Већина CP звезда су A и B спектралног типа, код којих је Штарково ширење главно од механизама ширења притиском.

5. НЕУТРОНСКЕ ЗВЕЗДЕ

Са побољшаном осетљивошћу рендгенских уређаја у космосу, расте интерес за спектралне линије код атмосфера неутронских звезда. Пошто је карактеристична густина у атмосфери директно сразмерна гравитационом убрзању на звезданој површини, мерењем ширења притиском апсорпционих линија директно се мери M/R^2, где су M и R маса и радијус звезде. Када се то повеже са мерењем гравитационог црвеног помака (пропорционалног са M/R), за исту или било коју другу линију или скуп линија, могу се одредити маса и радијус. Оваква мерења масе и радијуса не укључују удаљеност неутронске звезде, која је често недовољно прецизно позната, као ни величину емитујуће области [34].

Да бисмо добили грубу процену ширине спектралне линије за атмосферу неутронске звезде, можемо да проценимо ширину услед деловања најближег суседа (на растојању r_{nn}). Енергетска ширина линије Lyα коју изазива пертурбер са наелектрисањем z је [34]

$$W_{Stark} = \frac{6a_0 ze^2}{Zr_{nn}^2} = 6\left(\frac{4\pi}{3}\right)^{2/3} \frac{a_0 ze^2}{Z} N_{pert}^{2/3} \text{ eV}.$$

Овде је N_{pert} густина пертурбера, а Z наелектрисање језгра јона.

Ако изаберемо јединицу дубине Томсоновог расејања као одговарајућу референтну тачку, и интегришемо једначину хидростатичке равнотеже за изотермалну атмосферу температуре T, добија се да је карактеристична електронска густина за атмосферу неутронске звезде [34].

$$N_e = \frac{\mu m_p g}{\sigma_T kT} = 3.4\times10^{24}\, \mu M_{1.4} T_6^{-1} R_6^{-2} \text{ cm}^{-3}$$

Овде је μ средња маса по честици у јединицама масе протона m_p, g је гравитационо убрзање, σ_T Томсонов пресек, k Болцманова константа, $M_{1.4}$ маса звезде у јединицама 1.4 масе Сунца, R_6 радијус у јединицама 10^6 cm, и T_6 температура атмосфере у јединицама 10^6 K.

У квазистатичкој апроксимацији [34], претпостављајући да су електронско и јонско ширење упоредиви, Штаркова ширина спектралне линије за плазму у којој доминира водоник (z=1, $N_{pert} = N_e$, μ =1/2) је [34]

$$W_{Stark} \text{ [eV]} = 163\, Z^{-1} (M_{1.4})^{2/3} (R_6)^{-4/3} (T_6)^{-2/3} \text{ eV}.$$

Перелс [34] је за Lyα линију водонику сличног кисеоника нашао типичну Штаркову ширину од 20 eV, а од 60 eV за Lyβ.

6. ПРИМЕНА СЕМИКЛАСИЧНОГ МЕТОДА ЗА ИСТРАЖИВАЊЕ ШТАРКОВОГ ШИРЕЊА СПЕКТРАЛНИХ ЛИНИЈА У СРБИЈИ И АСТРОФИЗИЧКИ ЗНАЧАЈ ДОБИЈЕНИХ РЕЗУЛТАТА

Упркос чињеници да је најбољи теоријски метод за одређивање штарковски проширених профила спектралних линија квантно – механички метод јаке спреге, услед његове комплексности и нумеричких тешкоћа, постоји само мањи број оваквих прорачуна (види на пример референце у [36] као и [37-41]). Као пример доприноса чланова Групе за астрономску спектроскопију на Астрономској опсерваторији у Београду, можемо навести прво одређивање параметара Штарковог ширења у оквиру квантно-механичке теорије јаке спреге за један неводонични неутрални емитер (спектрална линија Li I 2s ^{2}S - 2p ^{2}P^o [42]).

У многим случајевима, као што су на пример комплексни спектри тешких атома или прелази између високопобуђених нивоа, квантно-механички метод је веома тешко, а често и практично немогуће употребити, те у таквим случајевима семикласични метод остаје најефикаснији метод за одређивање параметара Штарковог ширења.

Постојећи прорачуни већег обима изведени су коришћењем три различита компјутерска програма које су у основи разрадили (i) Џонс, Бенет и Грим (Jones, Benett и Griem [43-45]), (ii) Саал-Брешо (Sahal-Bréchot [46,47]) и (iii) Басало, Катани и Валдер (Bassalo, Cattani и Walder [48]).

Да би обезбедили што већи број података о Штарковом ширењу, потребних за истраживања астрофизичке и лабораторијске плазме, прорачун звезданих непрозрачности и моделирање атмосфера ових објеката, чинимо непрекидан напор да одредимо параметре Штарковог ширења за велики број линија у спектрима атома и јона. У низу радова, користећи семикласични пертурбациони формализам [46,47] који је био иновиран, осавремењен и оптимизован више пута (види нпр. [36,49-51]), одредили смо параметре Штарковог ширења за прелазе за које постоји довољно комплетан скуп поузданих атомских података, тако да се очекује добра тачност резултата (види на пример референце у [36] као и [52]).

До сада су публиковани резултати за 79 He, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 189 Ca, 32 Zn, 6 Au, 48 Ag, 18 Ga, 70 Cd I, 9 Cr I, 4 Te I, 25 Ne I, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 22 Ne II, 5 F II, 1 Cd II, 1 Kr II, 2 Ar II, 7 Cr II, 12 B III, 23 Al III, 10 Sc III, 27 Be III, 5 Ne III, 32 Y III, 20 In III, 2

Tl III, 5 F III, 2 Ne IV, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 2 Pb IV, 19 O V, 30 N V, 25 C V, 51 P V, 34 S V, 16 Si V, 26 V V, 26 Ne V, 30 O VI, 21 S VI, 2 F VI, 15 Si VI, 14 O VII, 10 F VII, 10 Cl VII, 20 Ne VIII, 4 K VIII, 9 Ar VIII, 6 Kr VIII, 4 Ca IX, 30 K IX, 8 Na IX, 57 Na X, 48 Ca X, 4 Sc X, 7 Al XI, 4 Si XI, 18 Mg XI, 4 Ti XI, 10 Sc XI, 9 Si XII, 27 Ti XII, 61 Si XIII и 33 V XIII појединачних спектралних линија и мултиплета.

Добијени семикласични резултати су упоређени са критички изабраним експерименталним подацима за 13 мултиплета He I [53]. Разлике између семикласичних резултата и експерименталних вредности су унутар граница од ± 20%, што су и предвиђене границе тачности семикласичног метода [45]).

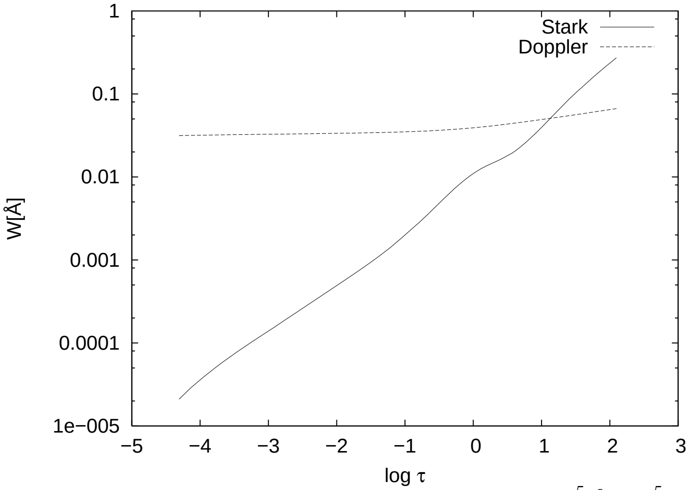
7. ПРИМЕНА ПАРАМЕТАРА ШТАРКОВОГ ШИРЕЊА ОДРЕЂЕНИХ СЕМИКЛАСИЧНИМ ПЕРТУРБАЦИОНИМ МЕТОДОМ ЗА ИСТРАЖИВАЊЕ УТИЦАЈА ОВОГ МЕХАНИЗМА ШИРЕЊА У ЗВЕЗДАНИМ АТМОСФЕРАМА

У низу радова истраживан је утицај Штарковог ширења на Au II [54], Co III [55], Ge I [56], Ga I [57], Cd I [58] и Te I [59] спектралне линије у спектрима атмосфера хемијски нерегуларних звезда А типа и за сваки испитивани спектар нађени су атмосферски слојеви, где је допринос овог механизма доминантан или се не може занемарити. Као модел хемијски нерегуларне звездане атмосфере А типа, у поменутим радовима је коришћен модел са условима у плазми блиским HgMn звезди А типа χ Lupi. Таква истраживања су изведена и за атмосфере белих патуљака DA, DB и DO типа [54, 55, 60], и установљено је да је за такве звездане атмосфере Штарково ширење доминантно у односу на Доплерово, у практично свим релевантним атмосферским слојевима.

Као пример утицаја Штарковог ширења у атмосферама врелих звезда на Сл. 2 је Штаркова ширина Te I 6s $^5S^o$ - 6p ^5P (9903.9 Å) мултиплета, упоређена са Доплеровом за модел (T_{eff} = 10000 K, log g = 4.5) атмосфере звезде спектралног типа А [61]. Наиме у атмосферама врелих звезда, Доплерово ширење је важан конкурентни механизам ширења спектралних линија, и упоређивањем Штаркове и Доплерове ширине може се закључити о значају ових механизама ширења. Треба имати у виду да се профил Доплеровски проширене линије описује Гаусовом расподелом а Штарковски проширене Лоренцовом. Због особина ове две расподеле, чак и када је Штаркова ширина линије мања од Доплерове, овај механизам може да утиче на крила линије. Резултати

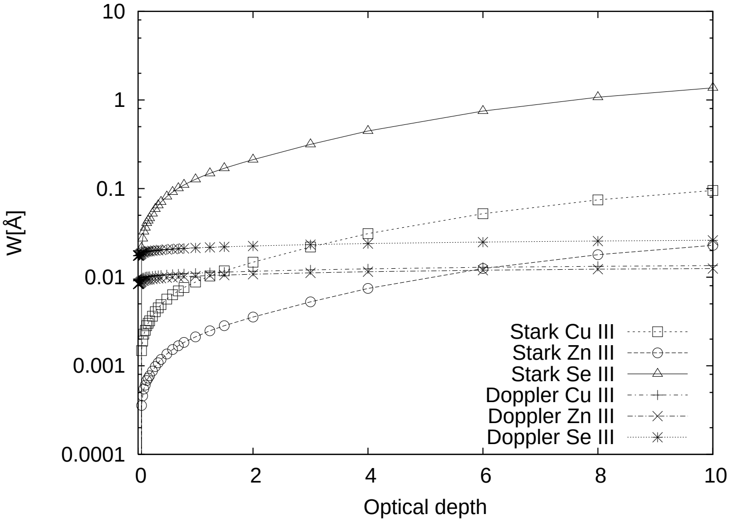
Симића и др. [59], представљени су на Сл. 2 у функцији Роселандове оптичке дубине – log τ. Може се видети да је механизам Штарковог ширења апсолутно доминантан у поређењу са термалним Доплеровим, у дубљим слојевима звездане атмосфере.

Утицај Штарковог ширења на линије Cu III, Zn III и Se III у спектрима атмосферама DB белих патуљака, истраживали су Симић и др. [58] за Cu III 4s ^2F - 4p $^2G^o$ (λ=1774.4 Å), Zn III 4s ^3D - 4p $^3P^o$ (λ=1667.9 Å) и Se III 4p5s $^3P^o$ - 5p ^3D (λ=3815.5 Å), користећи модел атмосфере са T_{eff} = 15000 K и log g = 7 [62]. За разматрани модел атмосфере DB белих патуљака мрежа тачка за оптичку дубину дата је у реф. [62] за стандардну таласну дужину λ_s=5150 Å (τ_{5150}) па је оптичка дубина тако претстављена и код Симића и др. [58].

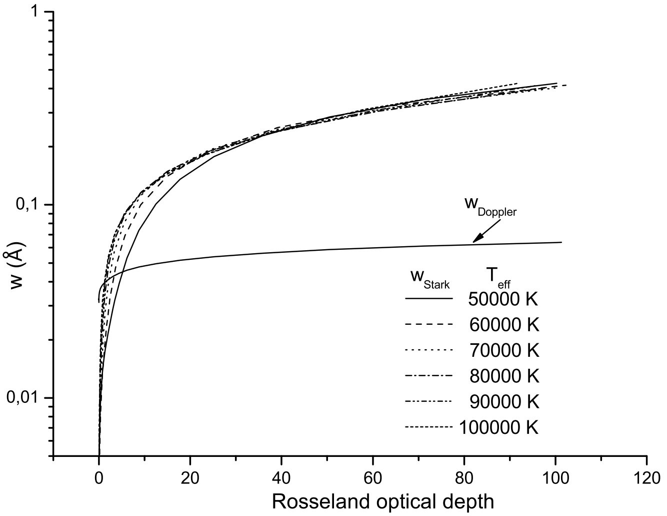


СЛИКА 2. *Термална Доплерова и Штаркова ширина за Te I 6s $^5S^o$ - 6p ^5P (9903.9 Å) мултиплет у функцији оптичке дубине за звезду спектралног типа A. (T_{eff} = 10000 K, log g = 4.5).*

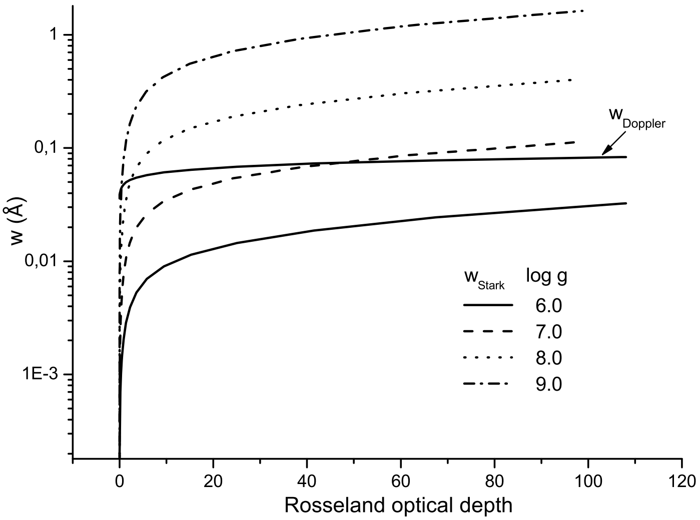
Као што се може видети на Сл. 3, за услове у плазми атмосфере DB белих патуљака термално Доплерово ширење има много мањи значај у поређењу са Штарковим ширењем. На пример Штаркова ширина за разматрану Se III 3815.5 Å линију је већа од Доплерове и до два реда величине у оквиру посматраног опсега оптичких дубина. Много веће Штаркове ширине у атмосферама DB белих патуљака, у поређењу са звездама спектралног типа A, су последица већих електронских густина услед много веће површинске гравитације и ефективне температуре,



СЛИКА 3. *Термална Доплерова и Штаркова ширина за спектралне линије Cu III 4s ^2F - 4p $^2G^o$ (λ=1774.4 Å), Zn III 4s ^3D - 4p $^3P^o$ (λ=1667.9 Å) и Se III 4p5s $^3P^o$ - 5p ^3D (λ=3815.5 Å), за модел атмосфере DB белог патуљка са T_{eff} = 15 000 K и log g = 7, у функцији оптичке дубине τ_{5150}.*



СЛИКА 4. *Штаркова и Доплерова ширина за спектралну линију Si VI $2p^4(^3P)3s\ ^2P$-$2p^4(^3P)3p\ ^2D^\circ$ (λ = 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за шест модела DO белих патуљака са ефективним температурама T_{eff} = 50 000–100 000 K и log g = 8.*



СЛИКА 5. *Штаркова и Доплерова ширина за спектралну линију Si VI* $2p^4(^3P)3s\ ^2P$*-*$2p^4(^3P)3p\ ^2D^{\circ}$ *(*λ *= 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за четири модела DO белих патуљака са log g = 6–9 и* T_{eff} *= 80 000 K.*

тако да је механизам ширења спектралних линија услед судара са електронима (Штарков) много ефективнији.

Хамди и др. [22] истраживали су утицај Штарковог ширења на Si VI линије у спектру DO белих патуљака за 50000 K $\leq T_{eff} \leq$ 100000 K и $6 \leq \log g \leq 9$. Установљено је да утицај расте са порастом log g и доминантан је у великим областима разматраних атмосфера, чији су модели узети из рада Весемела (Wesemael) [63].

На Сл. 4 и 5 представљене су Штаркова (FWHM) и Доплерова ширина за спектралну линију Si VI $2p^4(^3P)3s\ ^2P$-$2p^4(^3P)3p\ ^2D^{\circ}$ (λ = 1226, 7Å) у функцији Роселандове оптичке дубине. Штаркове ширине су дате за шест модела DO белих патуљака са ефективним температурама T_{eff} = 50 000–100 000 K и log g = 8 и четири модела са log g = 6–9 и T_{eff} = 80 000 K. За моделе звезданих атмосфера са већим вредностима површинске гравитације (log g = 8–9), Штарково ширење је знатно веће од Доплеровог. За звездане атмосфере са површинском гравитацијом log g = 7, Штаркове ширине су упоредиве са Доплеровим само за дубље, врелије слојеве. За моделе атмосфера са log g = 6, Доплерово ширење је доминантно за све анализиране слојеве атмосфере.

8. УТИЦАЈ ШТАРКОВОГ ШИРЕЊА И СТРАТИФИКАЦИЈЕ НА ЛИНИЈЕ Si I КОД roAp ЗВЕЗДЕ 10 Aql

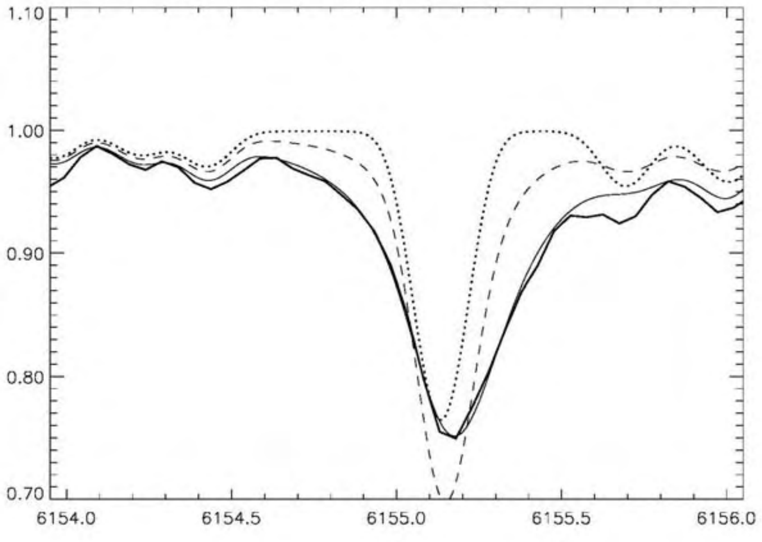
Као пример примене података о Штарковом ширењу у астрофизици може да послужи реф. [64] где је проучен утицај хемијске раслојености односно стратификације и Штарковог ширења на спектралне линије Si I, код брзо осцилујуће roAp звезде 10 Aql, где су линије Si I 6142.48 Å и 6155.13 Å асиметричне и померене. Аутори су прво израчунали параметре Штарковог ширења, користећи семикласични пертурбациони метод, за три спектралне линије неутралног силицијума: 5950.2 Å, 6142.48 Å и 6155.13 Å. Изменили су програм за рачунање синтетичког спектра тако да се узимају у обзир и Штаркове ширине и помаци за анализиране линије. На основу упоређивања теоријских прорачуна са посматрањима, нашли су да ефекти Штарковог ширења + хемијског раслојавања (стратификације) могу да објасне асиметрију Si I 6142.48 Å и 6155.13 Å линија.

За анализу, искористили су посматрања нормалне звезде HD32115, и две Ap звезде HD122970 и 10 Aql, као и Solar Flux Atlas [65]. CCD спектри високе резолуције 10 Aql и HD122970 су описани у раду Рјабчикова и др. [66]. CCD спектри високе резолуције (R приближно 45000) звезде HD32115 у опсегу таласних дужина 4000 -9500 Å добијени су помоћу coude-echell спектрометра монтираног на двометарски Цајсов телескоп на опсерваторији на врху Терскол у Русији (види Бикмаев и др. [67] за више детаља).

Велики број Ap звезда показује нерегуларне профиле линија Si I, али већина има јака магнетна поља која деформишу профиле линија преко Земановог цепања. Прилично слаба магнетна поља код Ap звезда HD122970 и 10 Aql, омогућују да се утицај магнетног поља на облик линије занемари.

Прорачун модела атмосфере, као и израчунавање коефицијента апсорпције, изведени су у апроксимацији локалне термодинамичке равнотеже (ЛТЕ). Рачунање модела атмосфере извршено је уз помоћ компјутерског програма ATLAS9 који је написао Р. Л. Куруц [68].

Следећи корак био је рачунање флукса ка посматрачу, у функцији (за одговарајућу мрежу тачака) таласне дужине, користећи дати модел. За то је узет компјутерски програм STARSP, који је написао В. В. Цимбал [69], и то измењена верзија, која израчунава синтетички спектар за атмосферу са вертикалним раслојавањем (стратификацијом) хемијских елемената.



СЛИКА 6. *Упоређивање профила спектралне линије 6155 Å неутралног силицијума, посматране у спектру Ap звезде 10 Aql (дебела линија) и синтетичког спектра израчунатог са Штарковом ширином и помаком из табеле 1 у реф. [54] и раслојавањем (стратификацијом) обилности силицијума (танка линија), са истим Штарковим параметрима али за хомогену расподелу силицијума (цртице), као и са Штарковом ширином узетом помоћу апроксимативне формуле за исто раслојавање силицијума (тачкаста линија).*

Прво су израчунали спектралне линије неутралног силицијума у спектру Сунца, да би проверили параметре Штарковог ширења и са поправљеним Штарковим параметрима синтетисали су профиле линија у спектрима звезда HD32115, HD122970 и 10 Aql.

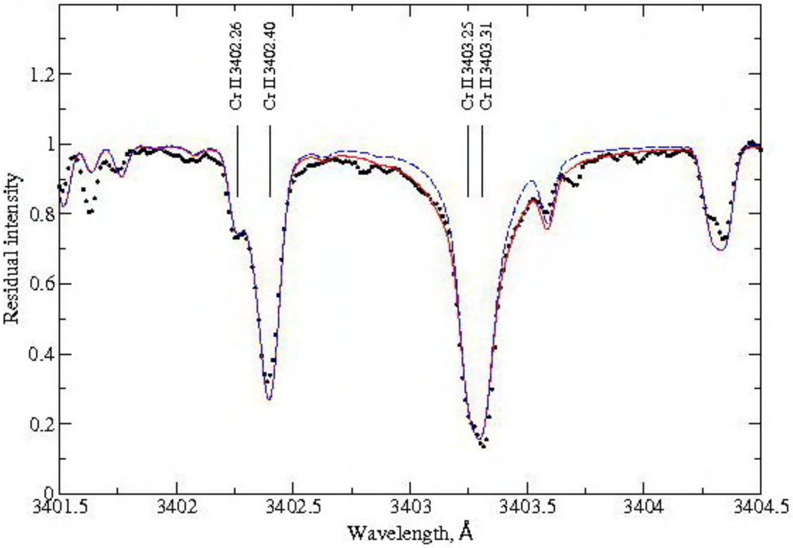
Звезда 10 Aql= HD176232 је најврелија у њиховом узорку. Има углавном асиметрични профил линије Si I 6155.13 Å, што се не може репродуковати ниједном комбинацијом параметара Штарковог ширења у хомогеној атмосфери. Чак и слабија, Si I 6142.48 Å линија, има значајан помак. Рјабчикова и др. [66] поменули су могућност раслојавања (стратификације) гвожђа и ретких земља у атмосфери 10 Aql. Они су покушали да нађу емпиријски, једноставну расподелу силицијума у 10 Aql, која би фитовала како Si I 6142.48 Å тако и 6155.13 Å линију. Добијена расподела даје разумно слагање посматраног и синтетисаног профила за обе силицијумове линије (Сл. 6). Штавише, чини се да иста расподела силицијума много боље фитује профиле јаких Si II 6347, 6371 Å спектралних линија, у поређењу са прорачунима са хомогеном Si обилношћу (-4.19), које су извели Рјабчикова и др. [66]. У својој анализи, аутори подвлаче, да са употребљеним параметрима

Штарковог ширења, осетљивост асиметрије 6155.13 Å линије на промене обилности Si у звезданој атмосфери, може бити успешно употребљена за емпиријска истраживања раслојавања обилности у атмосферама хладних Ap звезда.

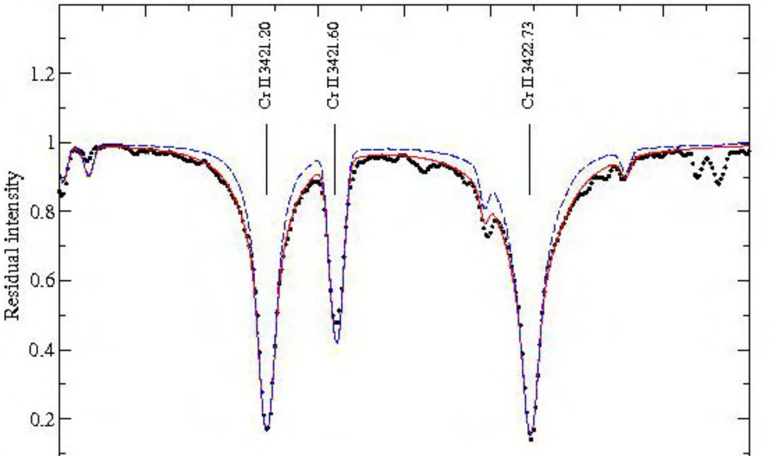
9. ШТАРКОВО ШИРЕЊЕ ЛИНИЈА ЈОНИЗОВАНОГ ХРОМА У СПЕКТРУ Ap ЗВЕЗДЕ HD 133792

Димитријевић и др. [70] су истраживали Cr II линије у спектру Ap звезде HD 133792, за које постоји пажљиво изведена анализа обилности и стратификације [71]. Звезда HD133792 има ефективну температуру T_{eff} = 9400 K, површинску гравитацију $\log g = 3.7$, и средњу обилност хрома +2.6 dex у односу на обилност овог елемента код Сунца [71]. Сви прорачуни су изведени са побољшаном верзијом SYNTH3 компјутерског програма SYNTH за прорачун синтетичког спектра. Штаркови параметри пригушења су унети у компјутерски програм. Употребљена је раслојена (стратификована) расподела хрома у атмосфери HD133972, изведена у реф. [71]. На Сл. 7 је посматрани профил линије Cr II 3403.30 Å, упоређен са синтетичким са параметрима Штарковог ширења из рада Димитријевић и др. [70] и Куруцовим [72]. Добро слагање посматрања и прорачуна за неколко слабих Cr II линија, потврђује употребљену расподелу раслојавања хрома, док слагање за све четири јаке Cr II линије, демонстрира добру тачност добијених теоријских параметара Штарковог ширења у реф. [70].

То отвара нову могућност, да се теоријски и експериментални резултати о Штарковом ширењу додатно провере помоћу звезданих спектара, чему нарочито могу да допринесу развој спектроскопије помоћу уређаја у космосу, изградња џиновских телескопа нове генерације и пораст тачности и поузданости компјутерских програма за моделирање звезданих атмосфера. Линије Cr II анализиране у реф. [70] су нарочито погодне за такву сврху, пошто имају добра и чиста крила, где је утицај Штарковог ширења најважнији.



СЛИКА 7. *Поређњење посматраног (тачке) профила линије Cr II 3403.30 Å, и синтетисаног са параметрима Штарковог ширења из рада Димитријевић и др. [70] (пуна линија) и Куруцовим [72] (испрекидана линија).*



СЛИКА 8. *Исто као на Сл. 7, само за линије Cr II 3421.20, 3422.73 Å.*

10. МОДИФИКОВАНИ СЕМИЕМПИРИЈСКИ МЕТОД ЗА ШТАРКОВО ШИРЕЊЕ И АСТРОФИЗИЧКЕ ПРИМЕНЕ

Модификована семиемпиријска теорија (MCE) [73,74] за прорачун параметара Штарковог ширења изолованих спектралних линија неводоничних јона, успешно је примењена много пута за различите проблеме у астрофизици и физици. Према MCE прилазу [73-79], пуна ширина изоловане јонске линје на половини максималног интензитета (FHWM) услед судара са електронима је

$$w_{MSE} = N\frac{4\pi}{3c}\frac{\hbar^2}{m^2}\left(\frac{2m}{\pi kT}\right)^{1/2}\frac{\lambda^2}{3^{1/2}}\left[\sum_{l_i\pm1}\sum_{L_{i'}J_{i'}}\Re^2_{l_i,l_i\pm1}\tilde{g}(x_{l_i,l_i\pm1})+\sum_{l_f\pm1}\sum_{L_{f'}J_{f'}}\Re^2_{l_f,l_f\pm1}\tilde{g}(x_{l_f,l_f\pm1})\right.$$

$$\left.+\left(\sum_{i'}\Re^2_{ii'}\right)_{\square n\neq0}g(x_{n_i,n_i+1})+\left(\sum_{f'}\Re^2_{ff'}\right)_{\square n\neq0}g(x_{n_f,n_f+1})\right],$$

а одговарајући Штарков помак

$$d = N\frac{2\pi}{3c}\frac{\hbar^2}{m^2}\left(\frac{2m}{\pi kT}\right)^{1/2}\frac{\lambda^2}{3^{1/2}}\left[\sum_{L_{i'}J_{i'}}\sigma J_i J_{i'}\Re^2_{l_i,l_i\pm1}\tilde{g}_{sh}(x_{l_i,l_i\pm1})\right.$$

$$-\sum_{L_{i'}J_{i'}}\sigma J_i J_{i'}\Re^2_{l_i,l_i-1}\tilde{g}_{sh}(x_{l_i,l_i-1})\sum_{L_{f'}J_{f'}}\sigma J_f J_{f'}\Re^2_{l_f,l_f+1}\tilde{g}_{sh}(x_{l_f,l_f+1})$$

$$+\sum_{L_{f'}J_{f'}}\sigma J_f J_{f'}\Re^2_{l_f,l_f-1}\tilde{g}_{sh}(x_{l_f,l_f-1})+\left(\sum_{i'}\Re^2_{ii'}\right)_{\Delta n\neq0}g_{sh}\left(x_{n_i,n_i+1}\right)$$

$$-2\sum_{i'(\Delta E_{ii'}<0)}\sum_{L_{i'}J_{i'}}\Re^2_{l_i,l_{i'}}g_{sh}(x_{l_i,l_{i'}})-\left(\sum_{f'}\Re^2_{ff'}\right)_{\Delta n\neq0}g_{sh}\left(x_{n_f,n_f+1}\right)$$

$$\left.+2\sum_{f'(\Delta E_{ff'}<0)}\sum_{L_{f'}J_{f'}}\Re^2_{l_f,l_{f'}}g_{sh}(x_{l_f,l_{f'}})+\sum_k\delta_k\right],$$

где је почетни енергетски ниво означен са i, крајњи са f, а сума квадрата матричних елемената $\Re$ за разлику главних квантних бројева $\Delta n \neq 0$, је

$$\left(\sum_{k'}\Re^2_{kk'}\right)_{\Delta n\neq0}=\left(\frac{3n_k^*}{2Z}\right)^2\frac{1}{9}\left(n_k^{*2}+3l_k^2+3l_k+11\right)$$

у Кулоновој апроксимацији. При томе је

$$x_{l_k, l_{k'}} = \frac{E}{\Delta E_{l_k, l_{k'}}}, \qquad k = i, f,$$

где је $E=3kT/2$ кинетичка енергија електрона, а

$$\Delta E_{l_k, l_{k'}} = \left| E_{l_k} - E_{l_{k'}} \right|$$

$$x_{n_k, n_k+1} \approx \frac{E}{\Delta E_{n_k, n_k+1}}$$

а за $\Delta n \neq 0$ енергетска разлика између нивоа са n_k и n_k+1 је процењена као

$$\Delta E_{n_k, n_k+1} \approx \frac{2Z^2 E_H}{n_k^{*3}}$$

при чему је

$$n_k^* = \left(\frac{E_H Z^2}{E_{ion} - E_k} \right)^{1/2}$$

ефективни главни квантни број, Z резидуално наелектрисање јона, односно наелектрисање остатка које „види“ оптички електрон, то јест електрон који врши прелаз (Z=1 за неутралне атоме, 2 за једноструко наелектрисане јоне ...) и E_{ion} одговарајућа граница спектралне серије. N и T су електронска густина и температура, док су са $g(x)$ [80], $\tilde{g}(x)$ [73] и $g_{sh}(x)$ [80], $\tilde{g}_{sh}(x)$ [74] означени одговарајући Гаунт фактори за ширину и помак. Фактор

$$\sigma_{kk'} = \frac{E_{k'} - E_k}{\left| E_{k'} - E_k \right|},$$

где су E_k и $E_{k'}$ енергије разматраног нивоа и нивоа који га пертурбује. Сума по δ_k

$$\delta_i = \pm \Re^2_{ii'} \left[g_{sh}\left(\frac{E}{\Delta E_{i,i'}}\right) \mp g_{sh}\left(x_{n_i,n_i+1}\right) \right]$$

$$\delta_f = \mp \Re^2_{ff'} \left[g_{sh}\left(\frac{E}{\Delta E_{f,f'}}\right) \mp g_{sh}\left(x_{n_f,n_f+1}\right) \right],$$

је различита од нуле само за оне пертурбујуће нивое, ако постоје, за које су јако нарушене претпостављене апроксимације.

У поређењу са потпуним семикласичним [45-47], и Гримовим семиемпиријским прилазом [80], за који треба практично исти сет атомских података као и за најсофистициранији семикласични, за модификовани семиемпиријски метод [73-79] потребно је знатно мање таквих података. У ствари, ако нема нивоа за које су претпостављене апроксимације јако нарушене, за прорачун Штаркове ширине, потребни су само енергетски нивои са $\Delta n = 0$, пошто је допринос свих нивоа са $\Delta n \neq 0$, који су потребни за потпуни семикласични прорачун и Гримову семиемпиријску формулу, приближно збирно процењен.

Услед потребе за знатно мањим бројем атомских података у поређењу са потпуним семикласичним пертурбационим [45-47], и Гримовим семиемпиријским прилазом [80], МСЕ метод је посебно користан за звездану спектроскопију, за коју су потребни атомски подаци и подаци о параметрима ширења за веома обимну листу елемената и спектралних линија, при чему није могуће у свим случајевима од интереса применити софистициране теоријске методе.

МСЕ метод је такође веома користан када су потребни подаци за веома велики број спектралних линија, а није неопходна велика тачност за сваку појединачну линију, као што су то на пример прорачуни преноса зрачења или моделирање плазме. Осим тога, у случају комплекснијих атома или вишеструко наелектрисаних јона, услед недостатка тачних атомских података потребних за прецизније прорачуне, поузданост семикласичних резултата опада. У таквим случајевима, МСЕ метод може такође бити интересантан.

11. УПРОШЋЕНА MCE ФОРМУЛА

За астрофизичке потребе, од посебног интереса може бити упрошћена MCE формула [76] за Штарково ширење изолованих линија, једноструко и вишеструко наелектрисаних неводоничних јона, примењљива у случају када је ниво најближи горњем и доњем нивоу прелаза, на који је могућ диполно дозвољени прелаз са почетног (*i*) или крајњег (*f*) енергетског нивоа разматране линије, тако далеко да је услов

$$x_{jj'} = E/\left|E_{j'} - E_j\right| \leq 2$$

задовољен. У таквом случају, пуна ширина на половини максималног интензитета дата је изразом [76]:

$$W(\overset{\circ}{\mathrm{A}}) = 2.2151\times 10^{-8}\frac{\lambda^2(\mathrm{cm})N(\mathrm{cm}^{-3})}{T^{1/2}\ (\mathrm{K})}\left(0.9-\frac{1.1}{Z}\right)\sum_{\mathrm{j=i,f}}\left(\frac{3n_j^*}{2Z}\right)^2\left(n_j^{*2}-l_j^2-l-1\right)$$

Овде, $E = 3kT/2$ је енергија пертурбујућег електрона, *Z-1* је наелектрисање јона, а *n** ефективни главни квантни број. Ова формула је од интереса за одређивања обилности, као и за истраживања звезданих атмосфера. Пошто су услови важења често задовољени у условима звездане плазме.

Слично у случају помака

$$d(\overset{\circ}{\mathrm{A}}) = 1.1076\times 10^{-8}\frac{\lambda^2(cm)N(cm^{-3})}{T^{1/2}\ (K)}\frac{9}{4Z^2}$$

$$\times\sum_{j=i,f}\frac{n_j^{*2}\varepsilon_j}{2l_j+1}\left\{\left(l_j+1\right)\left[n_j^{*2}-\left(l_j+1\right)^2\right]-l_n\left(n_j^{*2}-l_j^2\right)\right\}$$

Ако сви нивои који улазе у горњу суму постоје, може се извести додатно сумирање и добија се

$$d(\overset{\circ}{\mathrm{A}}) = 1.1076\times 10^{-8}\frac{\lambda^2(cm)N(cm^{-3})}{T^{1/2}\ (K)}\left(0.9-\frac{1.1}{Z}\right)\frac{9}{4Z^2}$$

$$\times\sum_{j=i,f}\frac{n_j^{*2}\varepsilon_j}{2l_j+1}\left(n_j^{*2}-3l_j^2-3l_j-1\right)$$

где је $\varepsilon = +1$ за $j = i$ и -1 за $j = f$.

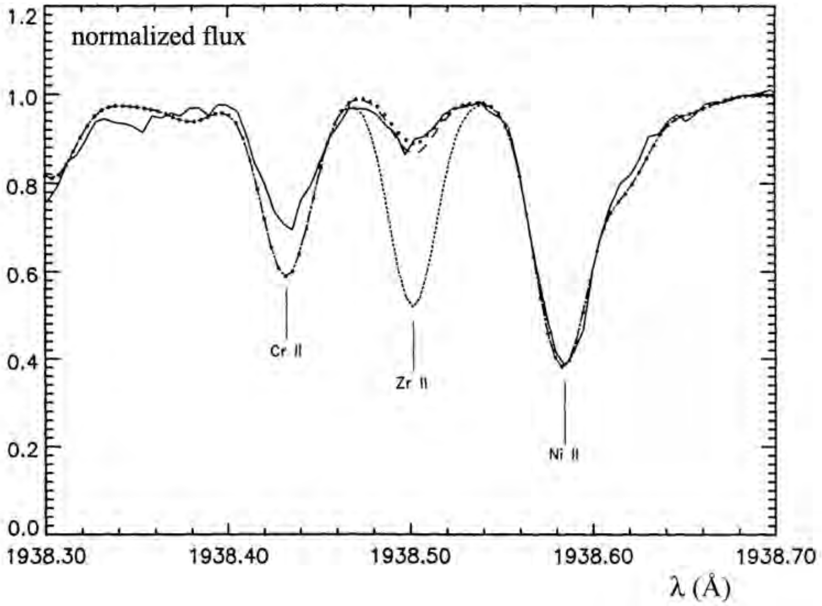
Модификовани семиемпиријски метод тестиран је више пута на бројним примерима [36]. Да би се проверио овај метод, експериментални подаци за 36 мултиплета (7 различитих врста јона) троструко наелектрисаних јона упоређени су са теоријским ширинама линије и добијени следећи усредњени односи мерених и теоријских вредности [73]: за двоструко наелектрисане јоне 1.06 ± 0.32 а за троструко наелектрисане 0.91 ± 0.42. Претпостављена тачност MCE формуле је око ±50%, али је показано [78,81,82] да чак и у случају емитера са веома комплексним спектрима (нпр. Xe II и Kr II), MCE метод даје веома добро слагање са експериментом (у интервалу ±30%). На пример за Xe II, 6s-6p прелазе, средњи однос између експерименталних и теоријских ширина линије је 1.15 ± 0.5 [81].

Израчунате су Штаркове ширине, а у неким случајевима и помаци, за спектралне линије следећих елемената: Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, Mn II, La II, Au II, Eu II, V II, Ti II, Kr II, Na II, Y II, Zr II, Sc II, Nd II, Be III, B III, S III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III, La III, V III, Ti III, Bi III, Sr III, Cu III, Co III, Cd III, B IV, Cu IV, Ge IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI, и Cl VI.

12. ПРИМЕНА НА ИСТРАЖИВАЊЕ „ЦИРКОНИЈУМСКОГ КОНФЛИКТА“ У АТМОСФЕРИ ЗВЕЗДЕ χ LUPI

Пример примене MCE формуле је разматрање „цирконијумског конфликта“ у атмосфери звезде χ Lupi [83]. Да би анализирали овај проблем, напоменимо да истраживања обилности за звезде раних типова показују да око 10% - 20% звезда A и B спектралног типа имају аномалије обилности, укључујући аномалије у изотопном саставу [83]. Аномалије обилности у овим звездама, које се зову CP звезде, проузроковане су различитим хидродинамичким процесима у спољашњим звезданим слојевима (који су потпомогнути и олакшани магнетним пољима, слабим звезданим ветровима, турбуленцијом, мешањем услед ротације итд.). Да би се истражили ови процеси, потребни су атомски подаци за много линија бројних емитера/апсорбера.

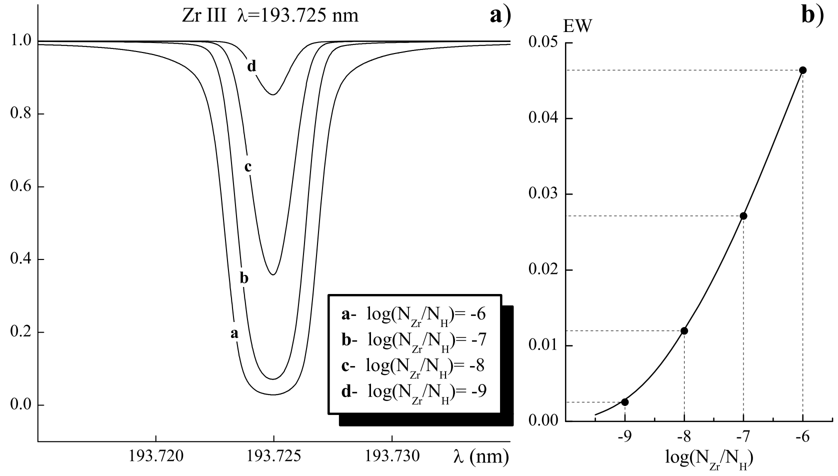
Линије цирконијума на пример, присутне су у спектрима HgMn звезда [26,84-86]. Занимљиво је да су обилности цирконијума одређене из слабих оптичких Zr II и јаких Zr III линија (које су откривене у UV) потпуно различите (види [26,86]) код HgMn звезде χ Lupi. Ово је илустровано на Сл. 9, на којој је приказан UV спектар ове звезде у опсегу таласних дужина 1938.3 - 1938.7 Å. Пуном линијом је означен спектар добијен помоћу GHRS. Тачкастом линијом је показана синтетисана Zr II 4d5s5p $^2D^o_{3/2}$ - 4d^{2}5s a$^2D_{3/2}$ λ=1938.5 Å линија, добијена за обилност цирконијума log $[N_{Zr}/N_H]$=-8.12. Ова вредност обилности је добијена помоћу Zr III спектралних линија. Испрекиданом линијом је означен синтетизовани спектар за обилност цирконијума log $[N_{Zr}/N_H]$=-9.1, а са већим тачкама за log $[N_{Zr}/N_H]$=-9.0 [26]. То је такозвани „цирконијумски конфликт“ и Сикстрем и др. (Sikström) [86] су претпоставили да је ова разлика вероватно последица неадекватног коришћења модела звезданих атмосфера, на пример ако није узет у обзир утицај не-ЛТЕ ефеката или дифузије.



СЛИКА 9. *UV спектар звезде χ Lupi у 1938.3 Å – 1938.7 Å опсегу таласних дужина. Пуном линијом је означен спектар добијен помоћу GHRS. Тачкастом линијом је показана синтетисана Zr II 4d5s5p $^2D^o_{3/2}$ - 4d^{2}5s a$^2D_{3/2}$ λ=1938.5 Å линија, добијена за обилност цирконијума log $[N_{Zr}/N_H]$=-8.12. Ова вредност обилности је добијена помоћу Zr III спектралних линија. Испрекиданом линијом је означен синтетизовани спектар за обилност цирконијума log $[N_{Zr}/N_H]$=-9.1, а са већим тачкама за log $[N_{Zr}/N_H]$=-9.0[26].*

Цирконијум, који у HgMn звездама често има много већу обилност него код Сунца (види [85]), је члан Sr-Y-Zr тријаде, која је веома битна за проучавање s-процеса нуклеосинтезе и указано је да представља не-нуклеарни образац обилности у HgMn звездама. Најочигледније објашњење ове аномалије је помоћу теорије дифузије, или укључивањем не-ЛТЕ ефеката. Ипак, од значаја је такође истраживање доприноса цирконијумском конфликту разлике параметара Штарковог ширења Zr II и Zr III спектралних линија.

Поповић и др. [83] су, користећи модификовану семиемпиријску формулу, одредили параметре Штарковог ширења услед судара са електронима за две астрофизички значајне Zr II и 34 Zr III спектралне линије, да би тестирали утицај овог механизма ширења линија на одређивање еквивалентних ширина и да би дискутовали његов могући утицај на одређивање обилности цирконијума.



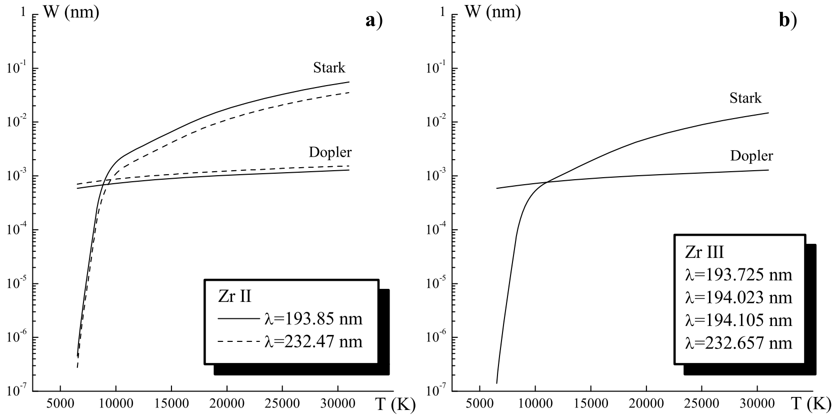
СЛИКА 10. *Промена профила линије Zr III* $4d^2\ {}^3P_1$ - $4d5p\ {}^3P^o_0$ λ*=1937.25 Å услед промене обилности цирконијума log* $[N_{Zr}/N_H]$ *за моделе звезданих атмосфера са* T_{eff}*=10500 K, log g=4.0 и турбулентном брзином* V_t*=0.0 km* s^{-1} *(a). На Сл. (b) је представљена еквивалентна ширина у функцији обилности цирконијума.*

Атомски енергетски нивои потребни за рачунање узети су из реф. [87,88]. Добијени резултати су употребљени да би се видело да ли ширење услед судара са електронима може да допринесе настанку такозваног „цирконијумског конфликта“ код HgMn звезде χ Lupi.

Да би се тестирао значај ефекта ширења спектралних линија услед судара са електронима за одређивање обилности цирконијума, Поповић и др. [83] су синтетисали профиле линија Zr II, λ=1938. Å и Zr III, λ=1940. Å, користећи компјутерски програм SYNTH [89] и Куруцов програм ATLAS9 за модел звездане атмосфере [72] са T_{eff}= 10500 K, log g = 4.0 и турбулентном брзином V_t=0.0 km s^{-1}, то јест за модел звездане атмосфере са карактеристикама сличним случају χ Lupi (T_{eff}=10650 K и log g=3.8, види Лекроне и др. (Leckrone) [90]).

Ове линије су изабране, зато што су биле уобичајено коришћене за одређивања обилности, пошто имају мали помак таласне дужине и добро су раздвојене [90]. Промена профила линије Zr III $4d^2\,{}^3P_1$ - $4d5p\,{}^3P^o_0$ λ=1937.25 Å услед промене обилности цирконијума, представљена је на Сл. 10а, док је на Сл. 10б приказана еквивалентна ширина у функцији обилности цирконијума

Поповић и др. [83] су израчунали еквивалентне ширине са и без утицаја ширења сударима са електронима за различите обилности цирконијума. Добијени резултати за ZrIII [194.0 nm] и ZrII [193.8 nm] линије показују да је ефекат ширења електронима значајнији за веће обилности цирконијума. Еквивалентна ширина расте са обилношћу за обе линије, али еквивалентна ширина за ZrIII [194.0 nm] линију је осетљивија него за ZrII [193.8 nm]. То може довести до грешке у одређивању обилности у случају када ефекат ширења сударима са електронима није узет у обзир. У сваком случају, синтетисање ове две линије да би се одредила обилност цирконијума, без узимања у обзир ширине услед судара са електронима, довешће да је обилност цирконијума одређена помоћу ZrIII [194.0 nm] линије већа него ако се одреди користећи ZrII [193.8 nm] линију. Ипак, овај ефекат не може да изазове разлику у обилности од једног реда величине.



СЛИКА 11. *Понашање Штаркових и Доплерових ширина (FWHM) са температуром, за моделе звезданих атмосфера са* T_{eff}*=10500 K, log g=4.0 и* V_t*=0.0$ км* c^{-1} *за а) Zr II* $4d5s5p\,{}^2D^o_{3/2}$ - $4d^25s\,a^2D_{3/2}$ *λ=193.85 nm (пуна линија) и Zr II* $4d5s5p\,y\,{}^2F^o_{5/2}$ - $4d^25s\,b^2G_{7/2}$ *λ=232.47 nm (испрекидана линија), и b) Zr III* $4d^2\,{}^3P_1$ - $4d5p\,{}^3P^o_0$ *λ=193.725 nm, Zr III* $4d^2\,{}^1G_4$ - $4d5p\,{}^1F^o_3$ *λ=194.023 nm, Zr III* $4d^2\,{}^3P_2$ - $4d5p\,{}^3P^o_1$ *λ=194.105 nm и Zr III* $4d^2\,{}^3P_1$ - $4d5p\,{}^3P^o_1$ *λ=194.657 nm. На Сл. 11б није показана зависност од температуре за све наведене линије пошто је приближно једнака.*

Премда се „цирконијумски конфликт“ код HgMn звезде χ Lupi не може објаснити само овим ефектом, треба узети у обзир да занемаривање Штарковог ширења може да доведе до грешака у одређивању обилности. Штавише на Сл. 11 је показано да је Штарково ширење упоредиво са Доплеровим или доминантно за температуре око 10 000 K и веће.

13. РЕТКЕ ЗЕМЉЕ У СПЕКТРИМА CP ЗВЕЗДА

Други пример применљивости MCE метода у астрофизици је истраживање спектралних линија елемената ретких земаља (rare earth element - REE) у спектрима CP звезда. Спектроскопски подаци за елементе ретке земље (REE) су од интереса за астрофизику пошто су линије јонизованих REE присутне у звезданим спектрима. Штавише, обилност REE у CP звездама је у широком опсегу температура много већа него на Сунцу (види нпр. Рјабчикова и др. [91]), и атомски подаци за REE су потребни да би се решавали астрофизички проблеми као што су релативне обилности елемената који настају у r- и s-процесима у Хало звездама сиромашним металима и еволуција CP звезда [92,93]. Обично се анализа обилности REE заснива на линијама првог јонизационог стања, за које постоје експериментално одређене јачине осцилатора. У неким CP звездама, на пример код HD 101065 [91], присутан је велики вишак REE.

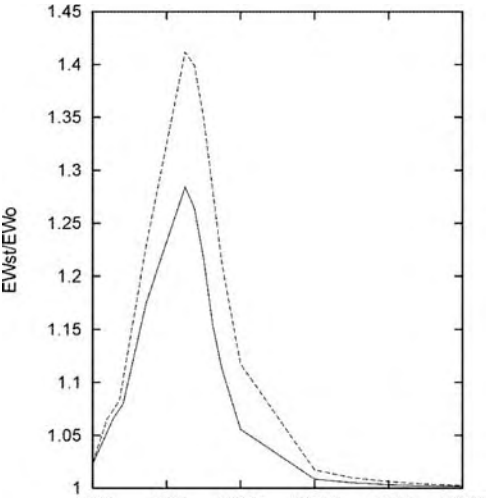
У Поповић и др. [91], израчунати су помоћу модификоване семиемпиријске формуле Штаркове ширине и помаци за шест линија Eu II и ширине за три La II и шест La III мултиплета. Помоћу добијених резултата истражен је утицај механизма ширења спектралних линија сударима са електронима у атмосферама топлих звезда. Показано је да је овај механизам ширења значајан у топлим звездама, и да треба да се узима у обзир код анализе звезданих спектралних линија за $T_{eff} > 7000$ K, посебно ако је обилност европијума велика.

У Поповић и др. [96], користећи MCE формулу, одређене су Штаркове ширине за 284 Nd II линије. Линије јонизованог неодимијума посматране су у спектрима CP, као и других звезда (види нпр. [94,97,98]). Услед услова у звезданим атмосферама, Nd II линије су доминантне у поређењу са Nd I и Nd III линијама. На пример у спектру roAp звезде HD101065, Каули и др. (Cowley) [94] су нашли 71 линију Nd II, а само 6 линија Nd I и 7 Nd III. Због тога се за одређивање обилности неодимијума код CP и других звезда, обично користе линије Nd II. Са друге стране, услед сложености Nd II спектра, веома је тешко добити атомске податке (јачине осцилатора, Штаркове ширине, итд.) потребне за астрофизичке сврхе.

Поповић и др. [96], су за прорачун Штаркове ширине користили упрошћени MCE прилаз Димитријевића и Коњевића [76]. Ова формула даје боље резултате него старија апроксимативна формула Каулија (Cowley) [99], често коришћена за процену Штаркове ширине када се не могу применити поузданији методи.

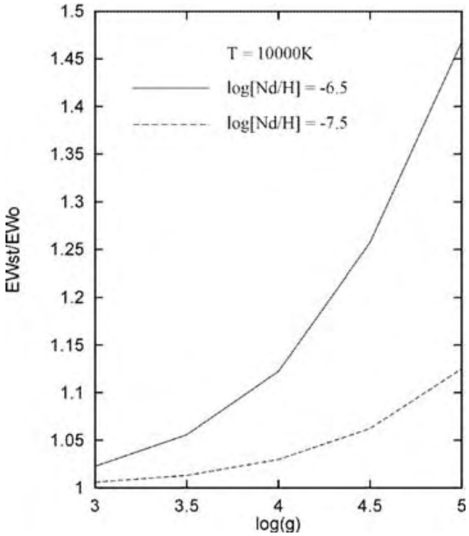
Да би тестирали значај ефекта ширења линија сударима са електронима у звезданим атмосферама, Поповић и др. [96] су синтетисали профиле 38 Nd II линија помоћу компјутерских програма за моделирање звезданих атмосфера SYNTH [89] и ATLAS9 [68], у температурском опсегу $6000 \leq T_{eff} \leq 16000$ K, и $3.0 \leq \log g \leq 5.0$.

Профиле линија су синтетисали са и без узимања у обзир Штарковог ширења сударима са електронима, за различите типове звезданих атмосфера. Прво су синтетисали све разматране профиле за обилност неодимијума A = log *[Nd/H]*=-7.0, и две вредности log g = 4.0 и 4.5 за различите ефективне температуре (T_{eff} = 6000 – 16000 K). Све разматране линије имају сличну зависност од ефективне температуре.



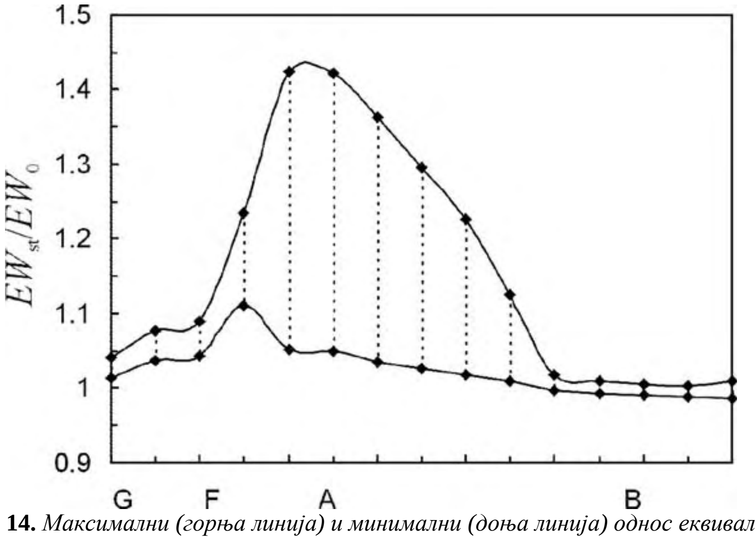
СЛИКА 12. *Однос еквивалентних ширина Nd II 4013.3 Å линије, израчунат са укључивањем Штарковог ширења (EW_{St}) и без њега (EW_0) у функцији ефективне температуре. Резултати за log g=4.0 и log g=4.5 приказани су пуном, односно испрекиданом линијом.*

Као пример, на Сл. 12 је показан однос еквивалентне ширине EW_{St}/EW_0 – као функција звездане температуре за линију Nd II 4013.3 Å. Као што се на слици може видети, највећи утицај ширења сударима са електронима на еквивалентну ширину је у опсегу ефективних



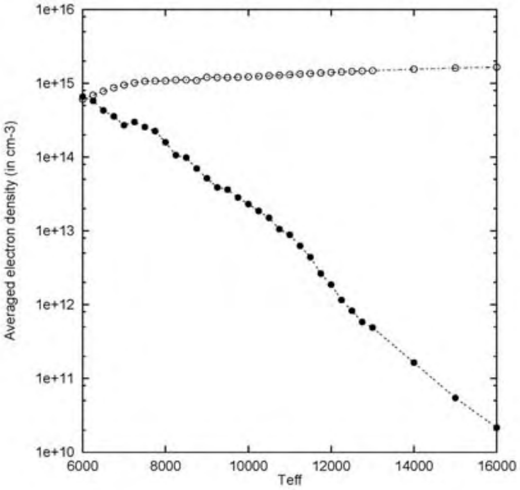
СЛИКА 13. *Однос еквивалентних ширина* EW_{St}/EW_0 *у функцији log g за Nd II 4062.2 Å спектралну линију, за две вредности обилности неодимијума.*

температура T_{eff} = 8000 K - 10000 K. Напоменимо да је вредност обилности неодимијума за Сунце -10.55, што је три реда величине мање од вредности коришћене на Сл. 12, тако да су Сунчеве Nd II линије слабе и релативно неосетљиве на ширину пригушења.



СЛИКА 14. *Максимални (горња линија) и минимални (доња линија) однос еквивалентних ширина* EW_{St}/EW_0 *за различите спектралне типове звезда, за 38 Nd II спектралних линија.*

На Сл. 13, илустрована је зависност од површинске гравитације, утицаја ширења линија сударима са електронима на еквивалентне ширине, за линију Nd II λ = 4062.2 Å и log [Nd/H] = -6.5 и -7.5. Утицај је већи за веће обилности неодимијума, и расте са порастом површинске гравитације.



СЛИКА 15. *Средње електронске густине у атмосфери (празни кругови) и у слојевима где је густина неодимијумових јона највећа (T=7000 K – 9000 K, испуњени кругови), у функцији ефективне температуре која одговара спектралним типовима звезда од G до B.*

Да би указали на спектралне типове звезда где је ефекат ширења линија сударима са електронима најзначајнији, Поповић и др. [96] су дали преглед укупног утицаја у различитим типовима звезданих атмосфера, разматрајући најмањи и највећи утицај на све проучаване линије. Овај резултат је показан на Сл. 14, где је приказан однос еквивалентних ширина у функцији спектралног типа звезде. Као што се може видети на Сл. 14, највећи утицај механизма Штарковог ширења је код звезданих атмосфера А типа.

Узимајући у обзир да Штарково ширење зависи од електронске густине (N), ефекат је највећи у атмосферама врелих звезда код којих је електронска густина већа, пошто водоник постаје јонизован. Може се очекивати да ће утицај Штарковог ширења бити већи за топлије звезде, али с обзиром да јон Nd II настаје у делу звездане атмосфере са одговарајућим параметрима плазме, то није случај. Полазећи од чињенице да је потенцијал јонизације Nd II 10.73 eV, и да слојеви где је густина јона Nd II највећа имају електронску температуру између 7000 K и 9000 K, Поповић и др. [96] су израчунали средњу електронску густину у овим слојевима звездане атмосфере за различите спектралне типове звезда и log g = 4.0. Како се може видети на Сл. 15, средња електронска густина опада са ефективном температуром. То је разлог зашто је највећи утицај ефекта Штарковог ширења у случају Nd II, код звезданих атмосфера А типа.

14. СРПСКА ВИРТУАЛНА ОПСЕРВАТОРИЈА И БАЗА ПОДАТАКА STARK-B

Српска виртуална опсерваторија је нови пројекат чије је финансирање одобрило Министарство за науку и технолошки развој Србије преко пројекта TR13022. Циљеви пројекта су:

- установити SerVO и придружити се EuroVO (Европска виртуална опсерваторија) и IVOA (International Virtual Observatory Alliance – Међународни савез виртуалних опсерваторија);
- установити SerVO центар података за дигитализацију и архивирање астрономских података добијених на Астрономској опсерваторији у Београду;
- развој алата за визуализацију података.

Главни циљ је да се публикују у VO компатибилном формату, подаци које су добили српски астрономи, као и да се астрономима у Србији обезбеде VO алати за научни рад. У прве три године главни циљеви пројекта су:

- дигитализција и публиковање у виртуалној опсерваторији фотографских плоча из архива Астрономске опсерваторије;
- публиковање, заједно са Париском опсерваторијом, базе података о Штарковом ширењу STARK-B, која ће, као први корак, садржати параметре Штарковог ширења, које су Димитријевић и Саал-Брешо добили у оквиру семикласичног пертурбационог прилаза током тридесетогодишње сарадње, у VO компатибилном формату;
- прављење мирор сајта за DSED (Darthmouth Stellar Evolution Database) у VO контексту.

У базу података STARK-B, улазе управо подаци о Штарковом ширењу о којима смо говорили у овом раду. Напоменимо да је претходник SerVO била BELDATA а њен главни садржај била је база података о Штарковом ширењу спектралних линија. Историја BELDATA може се следити у [100-104]. После интензивирања сарадње са француским колегама око базе података MOLAT на Парискoj опсерваторији, BELDATA је постала STARK-B.

Ова база података намењена је моделизацији и спектроскопској дијагностици звезданих атмосфера и омотача. Такође је од користи и за истраживања лабораторијске плазме, ласерски произведене плазме, инерцијалне фузије, као и за развој ласера и плазмене технологије.

Сходно томе опсег температура и густина који покривају табеле је широк и зависи од степена јонизације разматраног јона. Температура варира од неколико хиљада за неутралне атоме до неколико милиона Келвина за високо наелектрисане јоне. Електронска или јонска густина мења се од 10^{12} (случај звезданих атмосфера) до неколико пута 10^{23} cm^{-3} (субфотосферски слојеви и истраживања инерцијалне фузије).

Обезбеђена је проста графичка међувеза (интерфејс) са подацима (види http://stark-b.obspm.fr/elements.php). Корисник прво бира елемент из периодичног система који га интересује. После тога јонизационо стање, пертурбер(е), густину пертурбера, прелаз и температуру плазме, после чега се генерише табела са описом података, пуном ширином линије на половини максималног интензитета и помаком линије. Планирана су два мирор сајта, један у Медону и један у Београду.

Даљи развој ће бити да излазни подаци буду усаглашени са ВО стандардима (који тек треба да буду у потпуности дефинисани), као и да се база потхрани са још елемената /јонизационих стања. Ова база података улази и у европски ФП7 пројекта Виртуални центар за атомске и молекуларне податке (Virtual Atomic and Molecular Data Centre - VAMDC) први ФП7 пројекат у српској астрономији – чији конзорцијум чини 15 установа из 9 земаља. Његов циљ је да изгради доступну и интероперабилну е-инфраструктуру за атомске и молекуларне податке, проширујући и интегришући замашан број база података, за потребе различитих корисника у науци и индустрији.

15. ЗАКЉУЧАК

Као што се из изложеног може закључити, мултидисциплинарна област истраживања Штарковог ширења спектралних линија плазме у Србији има критичну масу и омогућава младима да се баве науком на светском нивоу и своје радове пласирају у врхунске међународне часописе. Оваква истраживања у астрономији имају и своју конференцију у Србији. I-III Југословенска конференција о облицима спектралних линија одржане су 1995,1997 и 1999, у Криваји код Бачке Тополе, Белој Цркви и Бранковцу на Фрушкој Гори, IV Српска конференција о облицима спектралних линија у Аранђеловцу 2003, а V-VII Српска конференција о облицима спектралних линија у астрофизици 2005, 2007 и 2009, у Вршцу, Сремским Карловцима и Зрењанину.

ЗАХВАЛНОСТ

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Collisions of emitters and absorbers with charged particles and stellar plasma

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Abstract. Collisions of emitters and absorbers with charged particles influence on spectral line shapes of stellar plasma, since due to splitting and shifting of atomic energy levels in electric field (Stark effect) lines in spectra are broadened and shifted. In this work is analyzed the importance of Stark broadening of such lines for analysis, interpretation and synthesis of stellar spectra, analysis, diagnostics and modelling of stellar plasma, and the significance of such results for investigations of laboratory, fusion and technological plasmas, as well as for the physics of lasers. It is considered for which types of stars and for which investigations Stark broadening is significant, and methods for theoretical determination of Stark broadening parameters of spectral lines are discussed. A review of such investigations on the Belgrade Astronomical Observatory is given as well.

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РАЗВОЈ И ПРИМЕНА БАЗА ПОДАТАКА У АСТРОНОМИЈИ И ФИЗИЦИ

DEVELOPMENT AND APPLICATION OF DATABASES IN ASTRONOMY AND PHYSICS

Отисак из публикације *Примењена физика у Србији*
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РАЗВОЈ И ПРИМЕНА БАЗА ПОДАТАКА У АСТРОНОМИЈИ И ФИЗИЦИ

М. С. ДИМИТРИЈЕВИЋ, Л. Ч. ПОПОВИЋ

Апстракт. У раду је приказан значај база података у физици и астрономији са примерима изузетно обимних прорачуна, који захтевају велики број података, начини на које се могу организовати и представити сакупљени подаци и преглед рада београдских физичара и астронома на овој проблематици, са посебним акцентом на рад у Лабораторији за гасну електронику Института за физику и на Астрономској опсерваторији.

1. ЗНАЧАЈ БАЗА ПОДАТАКА У ФИЗИЦИ И АСТРОНОМИЈИ

За низ проблема у физици и астрономији потребан је огроман број података, тако да је њихова организација у базе података свакако од великог интереса. Проблеми за које су овакве базе података посебно важне су, на пример, моделирање различитих плазми, синтеза спектара и прорачуни преноса зрачења. Интерес за веома велики број атомских података и података о сударним процесима и ширењу спектралних линија, посебно је стимулисан развојем сателитске астрономије. Развој компјутера такође је повећао потребу за великим бројем атомских, спектроскопских и других података, потребних за моделирање и истраживање различитих лабораторијских и астрофизичких плазми, као и плазми у технологији, светлосним уређајима, фузионим истраживањима, ласерски произведених плазми и слично.

Добар илустративан пример може да буде истраживање о непрозрачности класичних цефеида [1] где је 11 996 532 спектралних линија било узето у обзир (45 линија H, 45 He, 638 C, 54 N, 2 390 O, 16 030 Ne, 50 170 Na, 105 700 Mg, 145 200 Al, 133 700 Si, 12 560 Ar, 11 530 000 Fe).

Интересантно истраживање које је постало могуће развојем компјутерске технологије, јесте прорачун промене еквивалентне ширине спектралних линија са временом у звезданим јатима и галаксијама у којима се стварају звезде [2]. У овом истраживању израчунате су промене еквивалентних ширина појединих линија водоника и хелијума, у току пет стотина милиона година, и добијени резултати упоређени са посматрањима звезданих јата у Великом Магелановом облаку, суперзвезданим јатима у галаксији–"породилишту" звезда NGC 1569 и језгра патуљасте елиптичке галаксије NGC 205. Прорачун је изведен у две етапе. Прво је израчуната популација звезда различитих спектралних типова у функцији времена, а затим су синтетисани интегрални профили спектралних линија за цело звездано јато или галаксију, додајући доприносе спектара појединачних звезда.

За такве прорачуне потребан је изузетно велики број података. На пример, да би добио податке за јачине осцилатора и атомске енергетске нивое за један милион електронских везано–везаних прелаза у атомима и јонима, значајних за прорачун непрозрачности Сунца и звезда, као и известан број података о пресецима за фотојонизацију и о параметрима Штарковог ширења спектралних линија, Ситон је организовао 1984. године међународни "Opacity project" [3]. Резултат десетогодишњег рада на пројекту је база података (TOP Database [4–5]), која садржи углавном податке о јачинама осцилатора и енергетским нивоима.

У астрономији, велика количина посматрачких података публикована је у различитим звезданим каталозима. Најспектакуларнији каталог звезда астрономи су успели да направе тек када је у орбиту око Земље лансиран телескоп у потпуности посвећен оваквом послу. У част античког астронома који је израдио први каталог звезда, овај телескоп је назван тако да асоцира на његово име –Хипарх (HIPPARCOS – HIgh Precision PARallaxe COllecting Satellite). Лансиран је августа 1989. године, а звезде су помоћу њега посматране и проучаване од новембра 1989. до марта 1993. године. Помоћу телескопа са огледалом од 29 цм извршена су прецизна мерења положаја, паралакси и сопствених кретања 118.000 звезда, а резултат је изузетно прецизни звездани каталог који покрива целу небеску сферу. Поред тога урађен је и каталог нешто мање прецизности који обухвата податке за око 500.000 звезда, који је назван Тихо. Ови подаци су организовани и у базу података.

2. ВРСТЕ САКУПЉЕНИХ ПОДАТАКА И НАЧИНИ ЊИХОВОГ ПРЕДСТАВЉАЊА

Има неколико начина како да сакупимо корисне податке који би могли бити организовани у базу података.

- Пре свега можемо да сакупимо библиографске јединице или библиографске јединице са цитатима, што може бити организовано као књига или база података, као на пример Сциенце Цитатион Индех. М. С. Димитријевић је сакупио и објавио у пет књига [6–10] библиографију и индекс цитата о истраживању облика спектралних линија у Југославији од првог рада објављеног 1962. године, закључно са 2000.
- Подаци сакупљени из литературе или других извора су такође од интереса, као на пример познате таблице Националне лабораторије из Оукриџа, које садрже податке из атомске, молекуларне и физике пражњења.

- Посебно су корисни критички процењени прегледи података, као што су то, на пример, они о Штарковом ширењу спектралних линија, које је написао Никола Коњевић са сарадницима [11–16]. Приликом представљања сакупљених података треба водити рачуна да је изузетно корисна информација и извор података па и њихови аутори.
- Резултате астрономских посматрања ради одређивања прецизних положаја звезда, организоване у звездане каталоге, објављивали су сарадници Београдске астрономске опсерваторије Софија Сахаков, Миодраг Дачић, Зорица Цветковић, Душан Шалетић, Георгије Поповић, Милан Мијатов, Ђорђе Телеки, Ђура Божичковић и Веселка Трајковска [17–29]. Наша намера је да их у будућности организујемо у једну базу података.
- На Београдској и другим старим опсерваторијама налази се велика количина фотографских плоча са посматрачким подацима и у току је велики међународни напор да се они сакупе, дигитализују и организују у базе података доступне научној јавности.
- Часописи и публикације могу се такође сместити у базе података, омогућавајући, на пример, претрагу помоћу кључних речи.

3. АКТИВНОСТИ У БЕОГРАДУ НА САКУПЉАЊУ И ОРГАНИЗОВАЊУ ПОДАТАКА И ИСКУСТВА СА ЊИХОВИМ ОРГАНИЗОВАЊЕМ У БАЗИ

У Београду се продукција, сакупљање и критичка процена податка за моделирање и истраживање различитих процеса одвија у више лабораторија и група. Такви подаци се могу организовати у базе података и учињено је неколико покушаја у том смеру.

- Никола Коњевић са сарадницима објавио је неколико прегледа са критички процењеним експерименталним подацима о Штарковом ширењу [11–17], који су веома погодни за организовање у базу података.
- Ратко Јанев је објавио критички одабрани скуп података о сударним пресецима и брзинама реакција [30]. Касније, са искуством стеченим у Београду, радио је на сакупљању података и њиховом организовању у базу у Међународној атомској агенцији у Бечу.
- У Лабораторији за гасну електронику, на челу са Зораном Петровићем, неколико година се покушава да се организује база података за моделирање гасних пражњења.
- Група предвођена Миланом Курепом извела је бројна мерења различитих пресека за сударе између електрона и различитих молекула. Братислав Маринковић је покушао да заједно са Зораном

Петровићем формира заједничку базу података са подацима из Института за физику у Београду.

- На Астрономској опсерваторији у Београду сакупљено је и сакупља се много различитих теоријских и посматрачких података и од интереса је њихово уношење у базу података. Милан С. Димитријевић, Лука Ч. Поповић, Еди Бон, Ненад Миловановић и Владимир Бајчета направили су базу података БЕЛДАТА, која за сада садржи податке о Штарковом ширењу спектралних линија, а у даљем развоју у њу ће бити укључени звездани каталози, спектри активних галаксија и публикације Астрономске опсерваторије.

4. ЛАБОРАТОРИЈА ЗА ГАСНУ ЕЛЕКТРОНИКУ ИНСТИТУТА ЗА ФИЗИКУ: РАД НА БАЗАМА ПОДАТАКА

Основни интерес ове лабораторије су подаци потребни за моделирање гасних пражњења. То су пре свега пресеци за расејање електрона на молекулима. Приликом моделирања гасних пражњења неопходно је укључити СВЕ пресеке који постоје, значи да сет мора да буде комплетан и да задовољава захтев за прецизним описом размене импулса и енергије како би се добила добра функција расподеле. Процедура којом се модификују пресеци док се не добију транспортни коефицијенти који се слажу са експерименталним подацима назива се техникаројева [31]. Свака анализа овога типа представља критичку евалуацију постојећих пресека за расејање електрона и добијање комплетног сета није тривијално сакупљање, већ редовно подразумева модификације и ренормализације постојећих података. Такође сваки од ових подухвата подразумева и сакупљање, анализу и критичку евалуацију постојећих података за транспортне коефицијенте.

Постоје две подгрупе ових анализа. Прва укључује мерења ексцитационих коефицијената и њихову даљу анализу. Најбогатија колекција података ове врсте добијена је и постоји у лабораторији у Београду. Анализе података и добијање сетова пресека су у току и представљају сложен пројекат због великог доприноса виших побуђених нивоа и гашења побуђених стања кинетици нивоа. Друга подгрупа представља мерење коефицијената за захват у смешама добро познатих електропозитивних гасова и малих примеса електронегативних гасова, са циљем да се одреди коефицијент за захват мањинске компоненте [32–33].

Зоран Петровић је током једне године (1992) радио у Центру за податке у атомској и молекулској физици JILA Data Center, National Institute of Standards and Technology (NIST), где је припремио највећи део базе података за моделирање пражњења у аргону, која је имала за циљ да се створи стандардни модел за тестирање експерименталних резултата и модела добијених за референтну ГЕЦ комору. Поред комплета пресека за расејање електрона на основном стању аргона ова база података је садржала податке за расејање на побуђеним стањима аргона (ексцитацију, јонизацију), за процесе гашења побуђених стања у сударима, као и за сударе електрона јона и атома са површинама. Посебно је детаљно разматрана секундарна емисија електрона са површина, рефлексија електрона и рефлексија атома и јона. Због политичких разлога ова база података није завршена. JILA Data Center је угашен а подаци су продати фирми Kinema research. Како су делови ове базе били посебно прорачунати по молби Зорана Петровића, од стране сарадника америчких националних лабораторија, база није публикована у целини јер није постојало одобрење. Она је, међутим, у деловима презентирана, кроз моделе за сударе са ексцитованим честицама аргона [34–35]. Други, већи сегмент ове базе се односи на моделирање секундарне емисије електрона и презентиран је у Реф. [36], у којој је на основу тих података предложена нова феноменологија и нова теорија пробоја гасова на ниским притисцима која унапређује Таунсендову теорију.

Лабораторија за гасну електронику Института за физику у Београду поседује теоријске основе, нумеричке кодове и податке потребне за моделирање гасних пражњења у већини гасова од интереса. Она је интегрисана у међународне пројекте формирања база података у области плазма технологија и физике ројева. На основу ових података могуће је и формирање виртуелне фабрике, сета компјутерских програма за моделирање плазми, која је у стању да егзактно опише реактивне плазме и да обезбеди могућност пројектовања нових генерација плазма уређаја и њихове контроле током рада.

5. АКТИВНОСТИ НА АСТРОНОМСКОЈ ОПСЕРВАТОРИЈИ У БЕОГРАДУ НА САКУПЉАЊУ И ОРГАНИЗОВАЊУ ПОДАТАКА И ИСКУСТВА СА ЊИХОВИМ ОРГАНИЗОВАЊЕМ У БАЗЕ

На астрономским опсерваторијама се током времена сакупља све већа и већа количина посматрачких података и данас постоји више међународних пројеката за њихово дигитализовање и сакупљање у базе података, од којих се формирају виртуелне опсерваторије. На Београдској опсерваторији налази се велика количина фотографских плоча са посматрачким подацима, а осим тога поменули смо и публиковане звездане каталоге [17–29]. Поред тога образована је датотека са око 7.000 посматраних двојних звезда, која је сада постала незаобилазна референца при обради орбита двојних система [37]. Треба споменути и да Зоран Кнежевић учествује у развоју, одржавању и унапређивању међународног интернет сервиса AstDyS, који је постао референтни сервис за одређивање путањских елемената свих познатих астероида и стандардни извор података за планирање посматрања.

Поред библиографије и индекс цитата о истраживању облика спектралних линија у Југославији од првог рада објављеног 1962. године, закључно са 2000 [6–10], на Астрономској опсерваторији се годинама ради на истраживању и одређивању параметара Штарковог ширења спектралних линија. Да би потребне податке за истраживање и моделирање звездане и лабораторијске плазме допунили и подацима о параметрима Штарковог ширења, Милан С. Димитријевић и Силви Сахал-Брешо су у низу чланака дали резултате обимних прорачуна ових величина [38] у оквиру семикласичног прилаза [39–40], за велики број емитера. До сада су објављени резултати прорачуна за 79 He, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 189 Ca, 32 Zn, 6 Au, 48 Ag, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 22 Ne II, 12 B III, 23 Al III, 10 Sc III, 27 Be III, 5 Ne III, 32 Y III, 20 In III, 2 Tl III, 2 Ne IV, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 2 Pb IV, 19 O V, 30 N V, 25 C V, 51 P V, 34 S V, 26 V V, 30 O VI, 21 S VI, 2 F VI, 14 O VII, 10 F VII, 10 Cl VII, 20 Ne VIII, 4 K VIII, 9 Ar VIII, 6 Kr VIII, 4 Ca IX, 30 K IX, 8 Na IX, 57 Na X, 48 Ca X, 4 Sc X, 7 Al XI, 4 Si XI, 18 Mg XI, 4 Ti XI, 10 Sc XI, 9 Si XII, 27 Ti XII, 61 Si XIII i 33 V XIII мултиплета.

Да би се што је могуће боље употпунили ови подаци, Милан С. Димитријевић, Лука Ч. Поповић, Владимир Кршљанин, Драгана Танкосић, Еди Бон Ненад Миловановић, Саша Симић и Зоран Симић су користили Модификовани семиемпиријски прилаз [41] за емитере код којих атомски подаци нису довољно комплетни да би се могао извести поуздани семикласични прорачун. Ширине и у неким случајевима помаци најинтензивнијих спектралних линија следећих емитера су израчунати: Ar II, Fe II, Pt II, Bi II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, Mn II, La II, Au II, Eu II, V II, Ti II, Kr II, Na II, Y II, Zr II, Sc II, Be III, B III, S III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mn III, Ga III, Ge III, As III, Se III, Zn III, Mg III,La III, V III, Ti III, Bi III, Sr III, Cu III,B IV, Cu IV, Ge IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, V IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, Si VI, P VI, i Cl VI .

Да би се олакшало коришћење ових података, на Опсерваторији смо започели развој базе података БЕЛДАТА [42]. Прве фазе њеног пројектовања и израде су завршене. Пројектовани су и израђени база података, која служи као подршка веб интерфејсу, веб интерфејс за приступ подацима и претрагу и база података у којој се складиште каталози параметара Штарковог ширења добијени семикласичним приступом. До данас су у базу унети каталози за Al XI, Si XI, Si XII, Si XIII, Be I, Be III, B III, Ne VIII, O IV, O V, C V, P V, Sr I, P IV, S V, Ca IX i Ca X. Релационе базе података су реализоване коришћењем MySQL сервера база података. Веб интерфејс је реализован у PHP-у, Java Script-у i HTML-у.

Поред подака о параметрима Штарковог ширења, планирано је да у базу података уђу звездани каталози испосматрани на Београдској астрономској опсерваторији [17–29] Serbian Astronomical Journal i Publications of Belgrade Astronomical Observatory. Четврти део базе података биће посвећен спектрима активних галаксија. У базу података ће бити укључени спектри галаксија у FITS формату, које је на Криму посматрао К. К. Чувајев, као и сет спектара Активних галаксија посматраних са Исак Њутн телескопом (Северноевропске опсерваторије на Канарским острвима) од 21. до 25. 1. 2002. г., а који обухвата спектралне области Балмерове серије. Посматрано је укупно 12 активних галаксија (Mrk 1040, 3c120, NGC 3227, PG 1116+215, NGC 4253, Mrk 110, Mrk 141, REJ 1034+393, 3c273, Mrk 817, Mrk 493, Mrk 841) [43]. Поред тога, сва будућа спектроскопска посматрања на великим светским телескопима изведена од стране сарадника Астрономске опсерваторије биће прикључена овом делу базе.

Адреса базе података је http://www.aob.bg.ac.yu/BELDATA . То је прва база података у астрономији, која је у потпуности реализована у Србији.

ЗАХВАЛНИЦА

Аутори се захваљују Зорану Љ. Петровићу на подацима о раду Лабораторије за гасну електронику. Овај рад урађен је у оквиру пројеката "Утицај сударних процеса на спектре астрофизичке плазме" и "Астрофизичка спектроскопија вангалактичких објеката" финансираних од Министарства за науку, технологије и развој Републике Србије.

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M. S. Dimitrijević, L. Č. Popović**

DEVELOPMENT AND APPLICATION OF DATABASES IN ASTRONOMY AND PHYSICS

Summary

The importance of databases in physics and astronomy, with examples of exceptionally complex calculations needing a large number of data, has been discussed, as well as ways to organise and present the collected data. A review of achievements of Belgrade physicists and astrophysicists in this domain, with the special emphasis on the results of the Laboratory for Gaseous Electronics of the Institute of Physics, and of the Belgrade Astronomical Observatory, has been reviewed as well.

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Stark Broadening Parameters for Stellar Plasma Research: Bi III Spectral Lines

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Abstract. Stark widths (FWHM) for 5 Bi III transitions, for the electron density of $10^{23}\mathrm{m}^{-3}$ and temperatures from 5000 K up to 500000 K have been calculated by using the modified semiemprical approach.

Key words: spectral lines; profiles – atomic and molecular data

1. Introduction

Data on Stark broadening of stellar spectral lines are important for the consideration of various physical processes in stellar plasmas and for modelling and interpretation of stellar spectra. They are also of interest for the consideration of radiative transfer through subphotospheric layers, as well as for the laboratory and fusion plasmas and laser produced plasmas research. The development of space born high precision spectroscopy provides an additional interest for lines of trace elements.

Our objective is to provide to astrophysicists as well as for plasma physicists and others interested in such data, an as large as possible set of reliable Stark broadening parameters. We apply the semiclassical perturbation approach (Sahal-Bréchot, 1969ab), when the relevant reliable atomic data needed for the calculations with appropriate accuracy exist. If such set of atomic data is not sufficiently complete, or the semiclassical perturbation method can not be applied in an appropriate way, we apply the modified semiempirical approach, developed by Dimitrijević and Konjević (1980). For the case of ions with complex spectra the improvement was done by Popović and Dimitrijević (1996ab).

Within the semiclassical perturbation method, extensive calculations have been performed, up to now (Dimitrijević, 1996) for a number of radiators, and consequently, Stark broadening parameters for 79 He, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 12 B III, 23 Al III, 10 Sc III, 27 Ba III, 32 Y III, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 19 O V, 30 N V, 25 C V, 51 P V, 33 V V, 30 O VI, 21 S VI, 10 O VII, 10 F VII, 20 Ne VIII, 4 Ca IX, 8 Na IX, 48 Ca X, 7 Al XI, 4 Si XI, Si XII, 26 V XIII multiplets become available. Data for particular lines of F I, Ga II, Ga III, Cl I, Br I, I I, Cu I, Hg II, N III, F V and S IV also exist.

The width data for the most intensive lines for the following atom and ion species were calculated by us with the help of the modified semiempirical approach: Sc II, Ti II, Mn II, Fe II, Bi II, Pt II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, Y II, Zr II, La II, S III, Be III, B III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mg III, Mn III, Ga III, Ge III, As III, Se III, La III, Zn III, Cu IV, B IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, P VI and Cl VI.

Since the accuracy of the shift calculations is lower, shift values are not give when experimental data enabling an additional checking, are not availlable. We will determine here Stark broadening parameters of the Bi III spectral lines. Due to the unsuficient set of reliable atomic energy levels the modified semiempirical method is adequate for Bi III lines Stark broadening calculations, and was applied in this paper.

2. Results and Discussion

The analysis of obtained results and all details of calculations will be published elsewhere (Dimitrijević and Popović, 1998). Here are only presented in Table 1, Stark widths (FWHM) for 5 Bi III transitions, for the electron density of $10^{23}\mathrm{m}^{-3}$ and temperatures from 5000. K up to 500000. K. Atomic energy levels needed for calculations have been taken from Moore (1971). We hope that presented results will be of help for various problems of stellar and laboratory plasmas analysis and modeling.

Table 1. Stark full width (FWHM) of Bi III. The electron density is $10^{23}\mathrm{m}^{-3}$. The avaraged wavelength of the multiplet is denoted by $\overline{\lambda}$.

Transition	T (K)	W (nm)
	5000.	.211E-02
	10000.	.148E-02
$6p^2P^0_{3/2} - 7s^2S_{1/2}$	20000.	.103E-02
	50000.	.669E-03
$\lambda = 105.18$ nm	100000.	.548E-03
	250000.	.515E-03
	500000.	.487E-03
	5000.	.359E-02
	10000.	.251E-02
$6p^2P^0_{3/2} - 7s^2S_{1/2}$	20000.	.175E-02
	50000.	.113E-02
$\lambda = 134.61$ nm	100000.	.926E-03
	250000.	.871E-03
	500000.	.828E-03
	5000.	.559E-01
	10000.	.390E-01
$7s^2S - 7p^2P^0$	20000.	.272E-01
	50000.	.179E-01
$\overline{\lambda} = 394.61$ nm	100000.	.150E-01
	250000.	.144E-01
	500000.	.133E-01
	5000.	.369E-01
	10000.	.262E-01
$7s^2S - 8p^2P^0$	20000.	.200E-01
	50000.	.167E-01
$\overline{\lambda} = 165.00$ nm	100000.	.153E-01
	250000.	.126E-01
	500000.	.115E-01
	5000.	1.76
	10000.	1.25
$8s^2S - 8p^2P^0$	20000.	.943
	50000.	.784
$\overline{\lambda} = 956.66$ nm	100000.	.738
	250000.	.622
	500000.	.538

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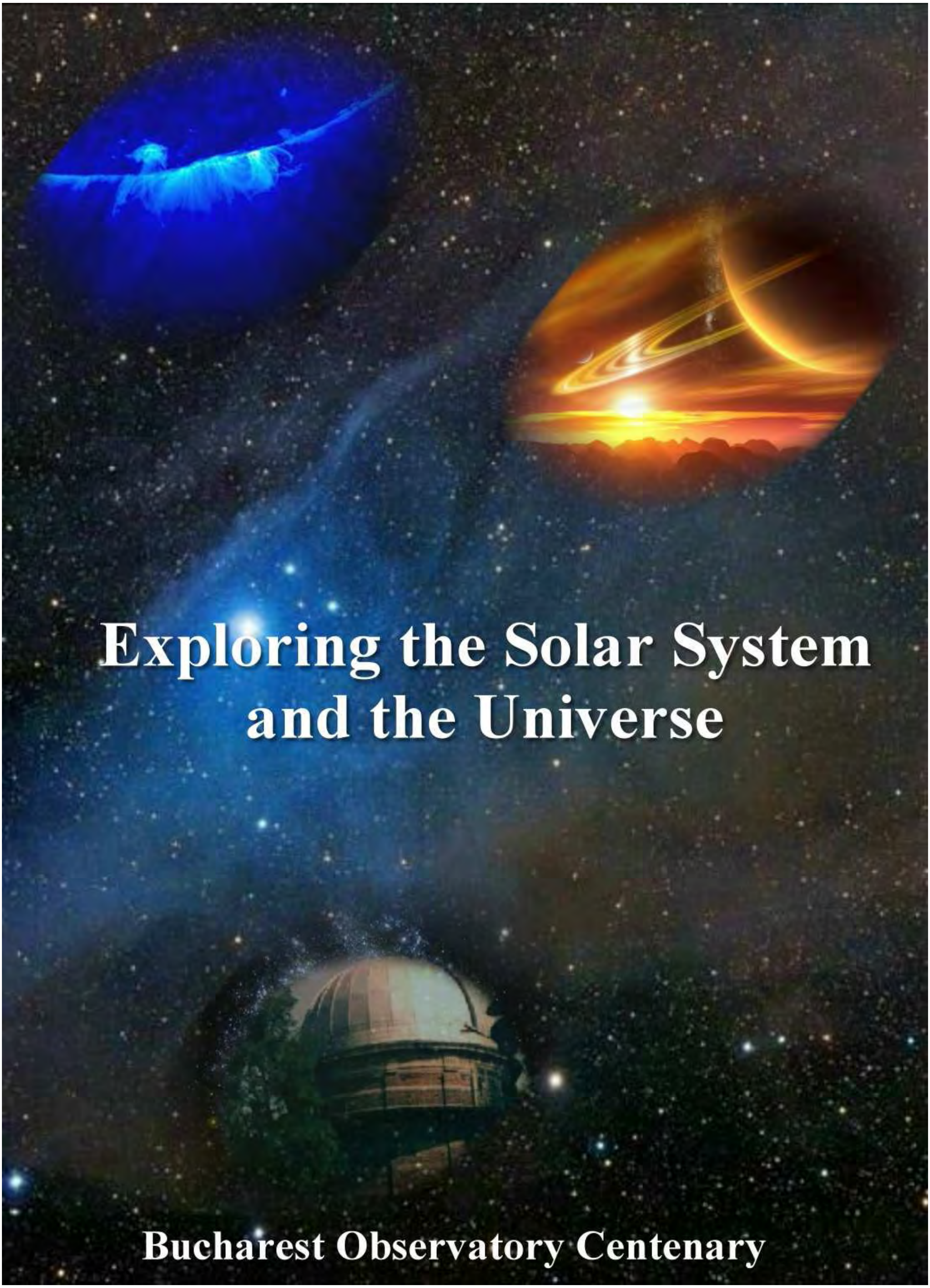

Exploring the Solar System and the Universe

Bucharest Observatory Centenary

ASTRONOMICAL INSTITUTE
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8-12 April 2008, Bucharest, Romania

ABSTRACT BOOK

Exploring the Solar System and the Universe

8-12 April 2008, Bucharest, Romania

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Vlad Turcu	Romania
Wojciech Dziembowski	Poland
Yavor Chapanov	Bulgaria
Zadig Mouradian	France
Zarko Mijajlovic	Serbia
Zeki Aslan	Turkey
Zhihong Jeff Xia	USA
Zoltan Mako	Romania

SYMPOSIUM 1

History of Romanian Astronomy, and Education by Astronomy in the European Framework

Convener:

Magda Stavinschi

Astrometry Knowledge in Geodetic Education

Octavian Badescu

Abstract:
In this paper we present the necessity of astrometric knowledge in geodetic education. Earth rotation, celestial reference systems and time scales are essential topics for many geodetic problems and techniques.

Astronomy Education in France

Chantal Balkowski

Abstract:
I will present the different levels of Astronomy education in France, at the university level through Master programmes, at school level through different programmes for teachers and children and at the public level through University diploma on line.

The Family of Nicolae Coculescu, the First Director of the Bucharest Observatory

Laurence Bennaceur

Abstract:
I am Laurence Servien Bennaceur, one of Nicolae Coculescu’s grand-children. Nicolae Coculescu married Lucrezia Popp. They had two children, Madeleine and Pius Serban. Madeleine studied French fantastic literature in Romania and obtained a thesis. Pius Serban came to France when he was about 16 years old. He graduated in Literature (thesis in the thirties) and Science from La Sorbonne University, as his father did. He became a researcher, published many books and gave lectures at the College de France and on the French radio. He was a scientist, a poet, a painter and a musician, and he worked on Aesthetics, a science which was the link between these different disciplines. He was in touch with many important personalities in France and in different European countries.

Remember on Some among Those who Passed/Crossed the Bucharest Astronomical Observatory

Elvira Botez

Abstract:
Determined by the centenary of the Bucharest Astronomical Observatory, the contribution provides a brief partial history of its first half of existence, by the active

presence - longer or episodic - in this institution of some astronomers; there are mentioned personalities involved in its setting up and also in its good working.

The Role of the Scientifical-Educational Center Kyiv Planetarium in Propagation of Astronomical Knowledge in Ukraine

Klim Churyumov

Abstract:

The scientific-educational center Kyiv Planetarium plays the great role in propagation of astronomical knowledge in Ukraine. Its main task, side by side with lecturing on astronomy and space physics for population, is also an active support of teaching astronomy in secondary and high schools. In the Planetarium educational astronomical programs are performed so as to be closely connected with school teachers of Kyiv and intended at introducing certain additions to the traditional school programs and therefore their expansion. They allow to better understand and to study deeper numerous astronomical phenomena and physical mechanisms of cosmic processes. In the Planetarium’s educational programs up-to-date scientific information about new discoveries in astronomy obtained with the help of the world largest telescopes, the Hubble Space telescope and space vehicles are made. Problems of modern astronomical education in Ukraine are discussed.

Astronomy in the Romanian Naval Education

Stelian Cojocaru, Mariana Pavaloiu

Abstract:

Celestial navigation has been, historically speaking, the most important pillar of the science of navigation over the centuries. Similar to modern ones, the ancient navigators sought to orientate in open seas and to find their position relative to the celestial bodies observed above the horizon. The lack of proper observational instrumentation prevented the navigators to use the astronomical references stars, planets, Sun and Moon to find their position at sea in a rigorous manner. This is why the first known application of a celestial method comes only at the end of 15th century, when Columbus during his voyages to America was determining his latitude using the Sun’s meridian observations. The practical method of longitude determination came long after, at the end of 18th century, when Harrison built the first marine chronometer (1761). With the sextant being invented in 1730, the navigators were finally able to determine both of their coordinates in a separate way. The method of determining the ship’s coordinates simultaneously came 50 years later, thanks to Sumner and Saint-Hilaire. Even more important than these practical achievements was the openness to the construction of a theoretical system for the celestial navigation. This contribution intends to present the celestial navigation in the general context of astronomy and to put into light the central role of astro-navigation in the mariner’s professional education. The structure of celestial navigation portion in the Romanian naval education system in the last 100 years, together with the most important contributions of Romanian authors, will conclude the paper.

Astronomy at the Observatoire de Paris at the Time of Notara's Visit

Suzanne Debarbat

Abstract:
When Notara (circa 1650-1731) came to Paris in 1700, after having spent three years in Padova, to pay a visit to Cassini (1625-1712), the Observatoire Royal was already built and the interiors achieved having received the visit of Louis the XIVth on 1682, May 1. Cassini was installed in an apartment situated on the first floor. He was French from 1673, married and having three children. As a member of the Academie Royale des Sciences as soon as his arrival, in 1669, he had met and worked with Picard, Huygens, La Hire, Roemer, others and their collaborators. Cassini had previously discovered four more satellites to Saturn, seen the Cassini Division, and tackled the mapping of France after Picard (1620-1682) and La Hire (1640-1718). When Notara arrived in Paris and came to the Observatoire Royal, Picard was dead, but his collaborator, La Hire, was still there and Cassini will just be on leave to pursue the determination of the reference meridian line in view of the complete mapping of France. This last subject retained mostly the attention of Notara in view of cartography of his native country. After applying the method employed by the French astronomers, he established a map and published, in 1716, a basic book on the matter to help his contemporaries.

Romanian-Serbian Collaboration in Astronomy

Milan S. Dimitrijevic, Magda Stavinschi

Abstract:
In this contribution we present and analyze the collaboration of Romanian and Serbian astronomers, from the time on collaboration on the reform of Julian calendar. We also analyze the data on mutual visits of Romanian and Serbian astronomers, obtained by perusing the Guest Book of Bucharest Astronomical Observatory and Annual Reports of Directors of Belgrade Astronomical Observatory published in various editions, as well as the history of four common meetings of Romanian and Serbian astronomers (Timisoara, Belgrade, Cluj-Napoca, Belgrade) organized by us.

Romanian Contributions to the International Heliophysical Year

Cristiana Dumitrache, Nedelia Antonia Popescu, Vasile Mioc

Abstract:
We present the Romanian activities within the framework of IHY. All part of IHY aspects will be approached: history, science, education and outreach. In the history aspect, we emphasize the beginning of solar and artificial satellite researches in Romania. As symmetry over times, after fifty years, the solar group started a new phase in its development and research themes, a fact that constituted itself in a challenge for educational programs and new scientific projects. A very important part of our activity during the International Heliophysical Year was the outreach.

Romanian Solar Physics Research in the Frame of International Cooperations (1955-2005)

Georgeta Maris

Abstract:

Valuable results of the Romanian solar physics research were obtained within the framework of the international collaborations. This contribution reviews the main cooperative programs as well as their results. The regular solar observations began at the Bucharest Solar Station simultaneously with the “International Geophysical Year” program, on June 1, 1957. At the beginning, there were carried out solar patrol observations. A long cooperation with the World Data Centers was based on the data obtained on active chromospheric phenomena as well as the relative sunspot number and the sunspot positions. A lot of solar observations were made during specific campaigns, in connection with some international programs. So, we took part in International Quiet Sun Years (IQSY, 1964-1965), Proton Flare Project (PFP, 1967), Rapid Variations of the Solar Magnetic Fields (1966-1974), INTERCOSMOS (1964-1977). However, there were some programs “forbidden” for us because of the totally unfavorable conditions for science in Romania before 1989. Some collaboration projects with the solar departments from other countries were set up within the framework of the cooperation between the Romanian Academy and similar institutions from abroad. The Romanian solar physics researchers acceded to JOSO since 1992 and new perspectives to collaborate were open. We also participated in the MEDOC Campaign (14-20 May 2001) and other special programs of solar active regions monitoring. We also notice the Romanian participation in the COST Action 724 (2004-2007) and Balkan, Black Sea and Caspian Sea Regional Network on Space Weather Studies (2005). On the personal basis, a lot of collaborations were developed with the research centers that offered training grants and PhD or post-doctoral grants to the young Romanian scientists.

Beginnings of the Modern Astrophysics in Bucharest Observatory

Harry Minti

Abstract:

The first astrophysical studies of solar activity began in 1955. The daily solar observations were communicated to Solar Observations centers beginning from the same year. Using a new Cassegrain 50-cm telescope installed in 1962, the first photoelectric observations of eclipsing binaries were performed in 1965 and were sent regularly to the Information Bulletin on Variable Stars of the Commission 27 of the IAU. As a young researcher, the author of this presentation has begun his activity under the learned influence of Professor Calin Popovici, the Chief of the Astrophysical Section. Solar activity and variable stars studies have forwarded to the introduction of the scientific research of astrophysical objects in the Astronomical Observatory of the Romanian Academy.

It All Started 50 Years Ago

Zadig Mouradian

Abstract:
I was student in astronomy at the Bucharest University and was finally recruited by the Bucharest Observatory to participate in the International Geophysical Year. I joined the Observatory on 1 June 1957 as the third fellow of the Solar Department. There, I became an expert in satellite affairs thanks to a TV broadcast shot at the Observatory. During the IGY I was in charge of adjusting the newly received solar instruments and contributed to the international campaign, including the solar patrol. Since it was absolutely impossible for me to start a thesis at that time, I moved to France and started a new career at the Solar Department of Paris-Meudon Observatory. My experience at the Bucharest Observatory was a fundamental start to the rest of my work for the next 50 years. My cooperation with the Bucharest Observatory amplified after 1992, and still continues today.

Decorative Elements with Astronomical Subjects on Medieval Buildings in Transylvania

Tiberiu Oproiu, Elisabeta Ana Pica

Abstract:
In this contribution we present several buildings from the Middle Age with astronomical subjects from Transylvania. In particular, there are analyzed sundials from churches and old houses situated in Cluj-Napoca, Alba Iulia and Sibiu towns. The investigations are performed according to the idea of International Astronomical Union Commission No. 41 (History of Astronomy) concerning the “Conservation of Astronomical Archives and Instruments”.

Astronomy in Fortress of Oradea

Nicoleta Pazmany

Abstract:
The relative recent “re-discovery”" of some documents related the existence of an early astronomical observatory and an elevated scientific and cultural environment in the early town of Oradea (Varadinum - first mentioned in AD 1113) was the starting point for that contribution. We present findings and some possible reconstruction of the so-called "zero meridian" from Oradea. History, events and records of past economic, cultural and scientific periods are outlined using original texts and archeological findings. The town developments in the Middle Age, the cultural and scientific life are correlated with the corresponding events in the Europe.

Romania before the International Year of Astronomy

Magda Stavinschi, Elisabeta Ana Pica, Catalin Mosoia

Abstract:
100 years of astronomical research in Romania happen almost at 400 years after Galileo Galilei first look at the sky with one of his instruments. However, there is a background that goes back in time further and makes specialists take into account that there is some kind of "cosmic feeling" throughout the Romanian culture. All contributes to a high level of public interest, be it students or general audience. In order to measure that we take into consideration the most important astronomical events organized at national level: Eclipse '99, Life in the Universe, Venus 2004, and EuroPlaNet. All experience gained at national level makes possible participation at international meetings and gives a high impulse of rehabilitation of science journalism where CAP2007 is the most recent example. Our work takes into account also educational projects and what we have learnt for celebrating the upcoming International Year of Astronomy.

Bucharest-Nikolaev Astronomical Observatories: Collaboration in Astronomy

Gennady Pinigin, Magda Stavinschi

Abstract:
Scientific collaboration between Bucharest Observatory of the Astronomical Institute (Romania) and Nikolaev Astronomical Observatory (Ukraine), based on the similar research directions and scientific traditions, starts from the beginning of 1990s. The main research field was positional astronomy with compilation of catalogues of star positions in the fields around selected ERS from the CCD observations in Nikolaev and photographic observations in the Bucharest Observatory. Another field of joint collaboration between both observatories was active work in the IAU Division I WG "The Future Development of Ground-Based Astrometry" and in the Sub-Regional European Astronomical Committee (SREAC) within the framework of the UNESCO-BRESCE funded Project "Enhancing Astronomical Research and Observation in SEE and Ukraine". Many conferences and workshops, mutual visits of astronomers from both observatories were organized and held in Nikolaev and Bucharest. At present, before the International Year of Astronomy 2009, a very useful collaboration between our observatories is taking place within the framework of the UNESCO thematic initiative "Astronomy and World Heritage".

Educational Actions of Some Greek Scholars in Romania

Peter Rovithis, Eleni Rovithis-Livaniou

Abstract:
The scientific work of some outstanding personalities - like Chrysanthos Notaras (1668-1732), Nikiforos Theotokis (1731-1800) and Benjamin Lesvios (1759-1824) - who acted and worked in Greece and Romania and contributed in the Cultural Heritage of

both countries will be presented and discussed. Their important role in the development and spreading of their times' science, mainly in Mathematics, Physics and Geography, will be referred, too.

Moments from Romanian Astronomy Education

Mircea V. Rusu, Magda Stavinschi

Abstract:

Selection from past astronomy education, activities, textbooks and curricula will be presented. Didactic aspects and comparison with physics education will be exemplified. The astronomy/science education along the time in Romania was divided in four directions: very broad information texts for everybody, especially for low education people, popular science (translations and/or original texts), school textbooks, and science fictions and astronomy/science literature, and exemplified using original texts. All categories were intended to extend literacy in science, but in different ways. The trends for different periods were outlined. Suggestions for future improvement of both related fields, physics and astronomy, would be one of the outcomes of our communication.

100 Years and More of Romanian Astronomy

Magda Stavinschi, Vasile Mioc

Abstract:

We present a survey of the astronomy on the Romanian territory along the history. We focus especially on the history of the Bucharest Observatory (created 100 years ago), on its achievements, on the persons that marked its set up and evolution. As the main component of the Astronomical Institute of the Romanian Academy (since 1990), the Bucharest Observatory had continuously increasing performances as regards achievements and links with the international astronomical community. We present today's situation and position in the European astronomical context.

Cosmology in Bucharest Observatory

Marian Doru Suran

Abstract:

At Bucharest Observatory cosmology began in the early '80s, as a theoretical branch, directly related to the computational facilities available in our Observatory. Starting from a little Z8080 computer (early '80s) to a superscalar supercomputer of 44 processors (now), our cosmology team developed models, methods and techniques related to: investigation of 2D and 3D catalogues of galaxies, clusters and superclusters; investigation of the log tails of the 2-points correlation functions; cosmological simulations (N-body + SPH) of the Large Scale Structure of the Universe (LSS); investigation of environmental effects in clusters of galaxies; application of neural methods in cosmology. The use of such models and techniques has permitted us to study problems related to: correlated signals in the long tail of the correlation functions for galaxies, clusters and superclusters (due to baryon oscillations); HD simulations of the LSS and of the evolution of the first and secondary Web structures; studies of the epochs of the formation of DM halos in a LCDM scenario (earlier than $z\sim15$); studies of the evolution of halos and galaxies due to the parental merging phenomena; decelation of the Butcher-Oemler and Oemler-Butcher effects in far or close clusters; studies of E+A galaxies; study of the synthetic spectra of galaxies and of the chemo-spectro-photometrical evolution of galaxies (for $z < 30$); photometric redshifts determination (for $z < 10$).

The First Astronomical Observatory in Cluj-Napoca

Ferenc Szenkovits

Abstract:

One of the most important cities of Romania is Cluj-Napoca (Kolozsvar, Klausenburg). This is a traditional center of education, with many universities and high schools. From the second half of the 18th century the University of Cluj had its own Astronomical Observatory, serving for didactical activities and scientific research. The famous astronomer Maximillian Hell was one of those Jesuits who put the basis of this Astronomical Observatory. Our purpose is to offer a short history of the beginnings of this Astronomical Observatory.

Rigas Velestinlis and Astronomy in His Anthology of Physics (For 250 Years from His Birthday)

Efstratios Theodossiou, Vasilis N. Manimanis, Milan S. Dimitrijevic, Emmanouel Danezis

Abstract:

Rigas Velestinlis (Velestino 1757 - Belgrade 1798) was a herald and martyr of freedom, but also one of the forerunners of the modern Greek enlightenment movement. With his restless intellectual researches, his books and publications, and his revolutionary ideas, he managed to participate in the intellectual awakening of his enslaved nation, channeling through his works the novel ideas of the European enlightenment together with the messages of French revolution. His vision was a great revolution, uprising of enslaved nations against Ottoman repression, which will result in the creation of a democratic community of nations of Balkans and neighbouring areas. An important part of his life he lived in Bucharest and tragically died in Belgrade, so that he is important for Romanian and Serbian history, too. For the history of astronomy, interesting is his Anthology of Physics, where astronomical contents are present. In this contribution, his life and work are presented and analyzed, with a particular attention to the astronomical aspects of the mentioned work.

European Virtual Observatory – Bulgarian and Romanian Cooperation: A Historical Overview

Milcho Tsvetkov

Abstract:
A general information of the European Virtual Observatory is described on the way of incorporation of the data sets of the Bulgarian and Romanian photographic plate archives. Since 1993 Bulgarian and Romanian institutes of astronomy started to collaborate actively for the establishment of the wide-field plate database with their photographic plate collection. The Bulgarian Institute of Astronomy was involved in the establishment of the IAU Commission 9 Wide-Field Plate Database, WFPDB (www.skyarchive.org), and one of the first astronomical institutes in the world that joined and actively collaborated in this direction was the Astronomical Institute of the Romanian Academy, and its director at that time, Magda Stavinschi. Due to the efforts from both sides, the Romanian Plate archive was one of the first included in the WFPDB and the only one updated with new observations up to the present moment. WFPDB now practically is the only virtual instrument for searching and investigation the photographic plate collection or individual plates to follow brightness behavior, etc. of every single sky object recorded mainly up to 14 mag in the period 1872-2005. More than 2,200,000 plates are listed in the WFPDB and for 530,000 we have plate index information available online every day updated. Romanian contribution provided one of the first digitized plate previews in the WFPDB, which allowed further data analyses of the plates exposed. Future plans of joint cooperation in the frame of recently Developed Data Center Alliance of the European Virtual Observatory (EURO-VO DCA) are also described.

SYMPOSIUM 2

Celestial Mechanics and Astrometry Today

Conveners:

Vasile Mioc

Petre Popescu

Spatial Families of Orbits in 2D Conservative Fields

Mira-Cristiana Anisiu

Abstract:

We consider the following version of the three-dimensional inverse problem of Dynamics: Given a spatial two-parametric family of curves, find the two-dimensional potentials under whose action the curves in the family are trajectories for a unit mass particle. First we establish the conditions which must be fulfilled by the family so that the potentials of the form W(y, z) give rise to the curves of the family. Then we examine the existence of potentials depending on (x, z), respectively (x, y), which are compatible with the given family and we present some applications.

Exploration of the Solar System: Projection of the Past into the Future

Jean-Eudes Arlot, Mirel Birlan, V. Robert, Valery Lainey, Dan Pascu, L. Winter, Jean-Pierre de Cuyper, Gheorghe Bocsa, Liviu Serbanescu, Evgeniya Khrutskaya

Abstract:

The exploration of the solar system from ground-based observations needs to make observations regularly, especially for the study of the dynamics of the planets, satellites, and small bodies. However, if we are able to make accurate astrometric observations nowadays, it would be more interesting to get information from the past. This will allow us to understand the evolution of their orbits, and to acquire clues for deciphering intimate physical characteristics. The project for new analysis and reduction of old photographic plates has been defined by several laboratories: the IMCCE (Paris Observatory), the US Naval Observatory (Washington, DC), the Royal Observatory of Belgium (Brussels), the Pulkovo Observatory (St Petersburg) and the Astronomical Institute of the Romanian Academy (Romania) are interested to scan and re-reduce plates of Pluto and of the satellites of Jupiter and Saturn. Thanks to the new catalogues such as the UCAC2 and waiting for Gaia catalogue, new results may help to refine the orbits of the solar system bodies and to discriminate secular terms using observations over long periods of time. New results obtained with the MAMA machine in Paris Observatory encourage us to continue these efforts using new accurate fast-measuring machines.

Geodetic Astronomy and Modern Astrometric Developments

Octavian Badescu, Petre Popescu, Alin Nedelcu, Petre Paraschiv

Abstract:

Modern astrometric developments are analyzed in connection with geodetic goals. CCD detectors, satellite technologies, radio astronomy, laser ranging techniques offer new and large perspectives for geodesy. Some results in this domain obtained in the collaboration between the Astronomical Institute of the Romanian Academy and the Faculty of Geodesy of the University of Civil Engineering are presented.

Astrometry in the Uranian System of Satellites

Mirel Birlan, Alin Nedelcu

Abstract:

In December 2007 occurred the equinox of the planet Uranus. Thus the Sun and the Earth are crossing the equatorial plane of planet Uranus. This provides the opportunity for an edge-on view of its equatorial plane from the inner solar system. Observations of the predicted occultation between the satellites Miranda and Oberon were obtained on July 30, 2007 using CSHELL IRTF located in Mauna Kea, Hawaii. Data analysis revealed that the predicted magnitude drop for this phenomenon was overestimated and we establish a high limit of 0.05 mag in detecting the phenomenon. Astrometry of the event was also obtained. The results and interpretation of this campaign will be presented.

The Study of the Dynamics of HD 180642 Area, from the COROT Programme

Gheoghe Bocsa

Abstract:

Using old (from 1939) and new (from 2004) photographic plates, we studied the dynamics of a star nearby the area HD 180642 using a centroid of stars included in the COROT programme.

Qualitative Study of the Plates Observed with the Photographic Equatorial of Bucharest Observatory since 1930

Gheorghe Bocsa, Petre Popescu

Abstract:

The study of the plates exposed with the Prin-Mertz refractor (f = 6 m, D = 38 cm) was performed and the results were included in the WFPA database. It was analyzed the next step of including the plate archive in Bucharest Virtual Observatory together with the new CCD observations.

Measuring and Scanning Methods in Astrometric Processing of the Photographic Plates

Gheorghe Bocsa, Milcho Tsvetkov

Abstract:
The paper is dedicated to the first comparative study concerning the position determinations of selected small bodies of the Solar System. These positions were observed with the Bucharest Observatory refractor (f = 6 m, D = 38 cm) and measured by means of Carl Zeiss ASCORECORD. The measurements and the processing of photographic plates were digitized with Epson 1640XL flatbed scanner.

Dust Particles of Comet Schwassmann-Wachmann 3 during its Return in 2006

Tanyu Bonev

Abstract:
Comet 73P/Schwassmann-Wachmann 3 split in 1995. One of its fragments was not found during the return of the comet in 2001. The next return, in 2006, was characterized by several cascading splitting events of the remaining fragments. About one month before perihelion the fragments approached Earth at distances less than 0.1 AU. We present analysis of the fragmentation events and address the question “Could some of the dust particles, released during the fragmentation, cross the orbit of Earth?”

Earth Rotation Response to ENSO Events

Yavor Chapanov

Abstract:
The Earth rotation response to ENSO is investigated by means of two approximations of the UT1-TAI variations according to the solution C04 of the IERS. The UT1 variations at ENSO frequencies are approximated by different sets of oscillations with periods between 2 and 5 years, whose superposition yields time series with behavior rather similar to the variations of ENSO Index. The delay of the Earth rotation response to the ENSO events is about 0.5a. The prediction ability of these models of Earth rotation response to ENSO events is analyzed by comparisons between the ENSO Index variations for the past epochs and the UT1-TAI backward extrapolation.

Influence of AAM and OAM on the Universal Time Variations

Yavor Chapanov, Daniel Gambis

Abstract:
Atmospheric Angular Momentum (AAM) and Ocean Angular Momentum (OAM) function excite Length of Day (LOD) variations and provides strong disturbances at large band of frequencies with periods from several days to years. The AAM and OAM affect also Universal time (UT1) variations and they appear as parasitical noise in some problems of parameters estimation. Corrections of AAM and OAM influence on UT1 are determined here by an integration of the AAM and OAM excitation functions of LOD after removing of their constant parts. The resulting series still contain significant linear trends for some intervals. The final UT1 corrections for AAM and OAM influence are determined by removing the residual trends. The obtained time series have good consistency in relation to the oscillations with periods from several days to 5 years and their application yields a more precise estimation of the periodical terms of the Earth rotation from this band.

Decadal Oscillations of the Earth Rotation

Yavor Chapanov, Jan Vondrak, Cyril Ron

Abstract:
The aim of the paper is to create a model of decadal variations of the universal time UT1 by means of long historical observational series of UT1 variations, which cover a time span more than one century. The model of decadal UT variations includes polynomial terms of power up to 3 and main oscillations with periods which represent the intrinsic frequencies of some natural phenomena: solar equatorial asymmetry - 45a; solar magnetic cycle - 22a; lunar node tidal oscillations - 18.613a; an empirical 12-year oscillation; sunspot variations - 11a; and 6-year oscillations from the band 5-7a. The coefficients of this model are determined by the least squares method. This model yields precise estimation of amplitudes and phases of the involved oscillations and better separations of the estimated terms with close frequencies.

Euler's Cone Aperture in the Euler-Poinsot Case

Monica Ciobanu

Abstract:
In order to explain the great discrepancy between Euler’s period and Chandler’s one, the author continued to analyze the Euler-Poinsot case. Results confirmed her previous findings regarding the period of Euler.

The Saari's Conjecture in Celestial Mechanics

Florin Diacu, Toshiaki Fujiwara, Ernesto Perez-Chavela, Manuele Santoprete

Abstract:

In 1970, D. Saari conjectured that the only solutions of the Newtonian n-body problem that have constant moment of inertia I are the relative equilibria. In the case n = 3, there exists a computer-assisted proof of this conjecture given by R. Moeckel in 2003. The extended Saari's conjecture establishes that, if along an orbit of the n-body problem IU^2 is constant, then the orbit is a homographic solution, that is, a solution where the configuration of the bodies is similar to itself when t varies; here U is the potential energy. In this talk, we give an analytical proof of this last conjecture in the case n = 3, for a huge set of initial data. Since I constant implies IU^2 is also constant, this result holds for the original Saari's conjecture.

Astronomical Principles of Satellite Positioning

Adrian Dragusan, Sergiu Lupu, Stelian Cojocaru

Abstract:

The Global Navigation Satellite Systems (GNSS) dominate the positioning technologies at the beginning of this millennium. The new concept, already common in all users' segments, refer to those radio-navigation systems providing highly precise time and position information, continuously and globally, disregarding the weather status. One can nominate GPS, GLONASS and GALILEO as exponents of GNSS concept; however, the only one global navigation system in full capability today remains GPS, with a clear perspective of modernization during the next decade. In the present paper, a comparison study of the theoretical principles of celestial navigation and satellite navigation is intended, offering sufficient reasoning to conclude that the roots of the global satellite navigation systems are, more than ever, connected to the classical principles of celestial navigation.

On the Local Equivalence between Manev and Kepler Problems

Vladimir Gerdjikov, Assen Kyuldjiev, Giuseppe Marmo, Gaetano Vilasi

Abstract:

We demonstrate the existence of a local Darboux chart for the Manev model such that its dynamics becomes locally equivalent to the Kepler model. This explains many of the similarities between these two models and why they share common symmetry algebras.

Error Statistics for Position Observations of Numbered Asteroids in Six Observatories of the World

Lyudmyla A. Hudkova, Anatolyi V. Ivantsov

Abstract:

More than 41 millions of positions for numbered asteroids were analyzed by the Minor Planet Center by December 25, 2007. Observations of six observatories (codes 089, 413, 568, 673, 689, 950) out of 398 observatories of the world were marked as high-accuracy by the Minor Planet Center. Consideration of observational accuracy is extremely important for the numerous applications of celestial mechanics. Comparison of the observed (O) positions, taken from the database of the Minor Planet Center for these six observatories, and calculated (C) ones using the HORIZONS ephemerides system is presented in the paper. Error statistics of the position observations were calculated using the (O-C) formulation. The subsequent analysis is given.

Position Observations of NEAs at the RTT-150

Anatolyi Ivantsov, Lyudmyla Hudkova, Zeki Aslan, Rusten Gumerov, Igor Khamitov, Gennady Pinigin

Abstract:

In 2004-2007, about 550 observations of 17 near-Earth asteroids (NEA) of 15-20.5 magnitude were made at the Russian-Turkish telescope (RTT-150). The reduction was made using the UCAC2 and USNO-B1 catalogues. The comparison of the observed and calculated positions through the HORIZONS system gave standard errors of a single position in 0.05-0.50″. Analysis of the (O-C) is given in the paper.

Parametric Influence on the 3D Motion of a Charged Particle in the Electromagnetic Field Produced by Two Co-Rotating Magnetic Oblate Dipoles

Tilemahos Kalvouridis

Abstract:

The systematic study of the motion of charged particles in the electromagnetic field of a rotating magnetic dipole started with Sturmer at the beginning of the 20th century. Sturmer, using a simple model and a robust mathematical formulation, tried to approximate some physical phenomena, such as the polar aurora, that take place in the neighbourhood of Earth. The problem of Sturmer re-opened in the decade of the 50’s after the discovery of the Van Allen belts. Since then, many improvements have been made in his original idea, while new models have been proposed, such as the one described by Tsyganenko, as well as the ‘magnetic-binary problem’ (otherwise called ‘the problem of two rotating dipoles’). In the former model, the simple simulation of the Earth’s field with a dipole is replaced by a very complex one, which represents the magnetic field of our planet in a more realistic manner. The latter model combines the restricted three-body problem and the initial idea of Sturmer and is more generally applicable since it takes into account the magnetic field of two celestial bodies (instead of merely one) that rotate about their common center of mass under their Newtonian gravitational attraction. It is therefore evident that the latter model presents more general interest in the scientific field of space dynamics, which is strengthened by the fact that more than 220 extra-solar planetary systems have been detected during the last ten years, some of which consist of two members that probably dispose magnetic fields. All these facts open new perspectives in the study of the problem and have provided us with the motive to explore some of its new aspects. In this work we shall consider that the two primaries are oblate spheroids and we shall try to reveal the influence of the parameters that characterize the problem on the equilibrium positions of the particle, as well as on the evolution of the zero-velocity surfaces that limit its three-dimensional motions. This consideration adds two new parameters to the existing ones in the classical case. The results show that for each set of parameters and for particular values of the Jacobian constant there are regions where the motion of the particle is bounded.

Results of CCD Observations of Ecliptic Zone in Nikolaev Observatory

Nadezhda Maigurova, Gennady Pinigin

Abstract:

Astrometric observations made with the Nikolaev observatory telescopes (Axial Meridian Circle and Fast Robotic Telescope) during 2003-2007 years are presented. The positions of more than 150,000 stars up to 16 magnitudes in the selected fields of ecliptic zone were obtained. The astrometric reductions were made by using reference stars from UCAC2 catalogues. Comparisons of positions with CAMC14 and 2MASS catalogues are discussed.

Chaotic Variation of the Capture Effect

Zoltan Mako

Abstract:

The gravitational ballistic capture is a phenomenon where a massless particle changes its Kepler-energy around one primary body from positive to negative. This capture is always temporary and, after some time, the Kepler-energy changes back to positive and the massless spacecraft leaves the neighborhood of the primary. Several authors studied the capture of small bodies by major planets, introducing different concepts of capture, like weak capture (Bebruno 1999; Belbruno and Marsden 1997), ballistic capture (Belbruno 2004), temporary capture (Brunini 1996), longest capture (Vieira and Winter 2001), resonant capture (Yu and Tremaine 2001). In all these studies the time is used as measure of the capture. In this presentation we try to study the phenomenon of capture using the variation of the angle of the small body around the capturing planet. We introduce the *capture effect* of the planet to the captured body as the total variation of the angle during the capture, as long as the Kepler-energy of the small body relative to the central planet is negative. The beginning moment of the capture is the moment when the Kepler-energy of the captured body, relative to the capturing body, becomes negative. The end of capture is the moment when the Kepler-energy becomes positive.

In this paper we show that the chaos of the capture effect is transient and we have an analytical relation between scattering function and capture effect.

A Double Pitchfork Bifurcation in the Generalized Henon-Heiles Problem

Vasile Mioc, Cristina Stoica, Daniel Pasca

Abstract:

The motion of a material point of unit mass in a generalized Henon-Heiles field is addressed for two limit situations: collision and escape. Using McGehee-type transformations, the corresponding collision and infinity boundary manifolds pasted on the phase space are determined. The dynamics on the collision and infinity manifolds is fully described. The topology of the flow on the collision manifold is independent of the parameters. In the full phase space, while spiraling collision orbits are present, most of the orbits avoid collision. The topology of the flow on the infinity manifold changes as the ratio between the field parameters C and D varies. More precisely, there are two symmetric pitchfork bifurcations along the line 2C - 3D = 0, due to the reshaping of the potential along the bifurcation line. Besides rectilinear and spiraling orbits, the near-escape dynamics includes oscillatory orbits, for which angular momentum alternates sign.

Ground-Based Science of ESA’s Rosetta Mission Targets: (21) Lutetia and (2867) Steins

Dan Alin Nedelcu, Mirel Birlan

Abstract:

The mineralogies of the asteroids (21) Lutetia and (2867) Steins were investigated in the framework of the ground-based science campaign dedicated to the encounter with the Rosetta spacecraft. Near-infrared (NIR) spectra of the asteroids in the 0.8-2.5 micron spectral range obtained with SpeX/IRTF in remote observing mode from Meudon, France, were analyzed together with previously acquired spectra. A chi-square test using meteorite spectra from the RELAB database was performed in order to find the best fit of complete visible + infrared (VNIR) spectra. For (21) Lutetia we find a clear spectral variation (slope), and a good correspondence between spectral variations and rotational phase. In the case of (2867) Steins the best-fit model for the constructed visible-plus-NIR spectrum is represented by a mixture of 57% enstatite, 42% oldhamite, and 1% orthopyroxene. These results place Steins in a subdivision of the E-type class with objects like Angelina, Eger, and Nereus. This group is not sampled by the current collection of aubrite meteorites.

Narrow-Field Astrometry with Different-Quality CCD Cameras

Petre Paraschiv, Octavian Badescu, Alin Nedelcu, Petre Popescu, Lubomir Iliev

Abstract:

PROTEL (Polar Robotic Telescope) programme involves studies and analyses for the correct choosing of the CCD detector. The performances of different CCD cameras were evaluated in tests performed in Belogradchik Observatory using the 60-cm Zeiss telescope. The studies involved the evaluation of: image quality, resolution, reliability, transfer rates, connectivity and temperature behavior.

A Pilot Astrometric Survey of 59 Northern ICRF Radio-Sources

Petre Popescu, Alin Nedelcu, Marcelo Assafin, Octavian Badescu, Petre Paraschiv, Lubomir Iliev, Alexander Antov

Abstract:

To investigate the link between the ICRF and the Hipparcos Catalog Reference Frame (HCRF) (IAU 2002), the most straightforward approach is from the astrometry of ICRF sources in the optical domain. In 2004 we have started, at the Belogradchik Observatory, Bulgaria, an observational program aiming at densifying the northern hemisphere coverage with precise astrometric ICRF source positions based on the UCAC2. Here we present pilot results for 59 sources.

The Dumb-Bell’s Restricted, Photogravitational, Circular Three-Body Problem

Rodica Roman, Tiberiu Oproiu

Abstract:

We study the dumb-bell’s planar motion within the framework of the photogravitational restricted three-body problem. The main topic of this paper is the connection between the translation and the spin motion of the dumb-bell, under the action of a photogravitational field generated by a binary system. The dumb-bell’s equations of motion in the orbital plane are established, first using an inertial reference system, and then a rotating one. A first integral of Jacobi-type is found. Then the equipotential surfaces and the equilibrium points are analyzed. A geometrical feature of equilibrium points is established.

Reflections on My Conjecture, and Several New Ones

Donald Gene Saari

Abstract:
Simplifying assumptions used to determine the mass of galaxies include requiring the moment of inertia of the system to be constant. While this appears to be innocuous, over 30 years ago I conjectured that this meant that the system was highly constrained; I suspected that it required the system to behave like a rigid body rotating in space. In this lecture, I will describe the history of my conjecture, point out other challenges, and describe some of the advances that have been made.

Constant Inertia Trajectories, Saari's Conjecture and More

Cristina Stoica

Abstract:
The simplest non-collision solutions of the N-body problem are the relative equilibria, in which each body follows a circular orbit around the center of mass and the shape formed by the N bodies is constant. It is easy to see that the moment of inertia of such a solution is constant. In 1970, Saari conjectured that the converse is also true for the planar Newtonian N-body problem: relative equilibria are the only constant-inertia solutions. To this day, although it is believed to be true, Saari's conjecture lacks a conceptual proof. This talk reports on two extensions to Saari's conjecture. First, we present a generalization in the context of simple mechanical systems with symmetries. We show that if a simple mechanical system with n degrees of freedom is symmetric under the free linear action of a k-dimensional Lie group where $k(k+1)/2 = (n-k)$, then a version of Saari's conjecture holds except at specific isolated points. Second, we present proofs that several generalizations of Saari's conjecture are generically true (in topological sense). Our main tool here is jet transversality, including a new version suitable for the study of generic potential functions.

The LQAC Compilation of the Quasars Catalogues

Jean Souchay et al.

Abstract:
The always increasing number of recorded quasars leads to make a general compilation of these objects by taking into account the astrometric, photometric, radio and redshift information. This work was achieved at Paris observatory under the acronym of LQAC (Large Quasar Astrometric Catalogue). We present the various improvements brought by this compilation.

Rehabilitation of Plate Information

Liviu Serbănescu

Abstract:

In the digitized information from the plates archive errors may occur, caused by several factors as: physical degradation of the plates, the digitization process (from scanning, photographing, etc.), measuring processes (to obtain the coordinates for certain celestial objects that are on that plate), etc. Comparing common areas with similar measuring methods, models for the distribution of errors may be determined (for errors that may occur during digitization process, respectively the measurement process), or evolution models of the errors (in the case of used plates). These models may be used to compensate the occurring errors or to delimit them. In a digitized database, the comparing operations for common areas may be done automatically by the software, having as result the determination of the identical areas from star catalogs with minimal tolerance from the measurement and classification point of view, and having as result fuzzy models for the occurring errors. Using these fuzzy models, digitized plates library may give information regarding the level of "trust" of each digitized image.

On the Elliptic Restricted Three-Body Problem

Ferenc Szenkovits

Abstract:

The elliptic restricted three-body problem (ERTBP) describes the three-dimensional motion of a small particle under the gravitational attraction of two bodies (the primaries), which describe elliptic orbits in a plane around the centre of mass. Szebehely and Giacaglia (1964) obtained in the planar ERTBP a simple form of the equations of motion - similar to that in the case of the circular restricted three-body problem - by using the true anomaly of the primaries as the independent variable and by introducing a special set of dimensionless variables describing the position of the third body. They also deduced an invariant relation, the generalization of the Jacobian integral, known in the circular restricted three-body problem, and proved the pulsation of the zero velocity curves in the planar case. In this study new results concerning the ERTBP are presented. These results are related to the three-dimensional generalization of Szebehely's invariant relation to the properties of the variable zero-velocity surfaces determined by using the invariant relations, and to possible applications of these results.

Manev's Field Problem in Contemporary Science

Katya Tsvetkova, Vasile Mioc

Abstract:

The Bulgarian physicist Georgi Manev proposed a gravitational field with a potential $A/r + B/r^2$, where A and B are real parameters, as a classical alternative to special relativity in the period 1924-1930. Since 1993 his ideas have found new applications in the celestial mechanics, theoretical and gravitational physics (the so-called Manev-type field) thanks to the systematic research initiated by the Romanian mathematicians and astronomers. The international conference dedicated to scientific legacy of Professor Georgi Manev and its reflection in the contemporary astronomy, theoretical and gravitational physics, gathered in Sofia in May 2004 physicists, astronomers and mathematicians, and stimulated significantly the work in this field. On the basis of the updated Manev's Field Bibliography Data Base (publications based on this problem or which refer to it), we present here the publication metrics and some statistical results.

Astrometric Plates in the Bucharest and Cluj Observatories Archives

Katya Tsvetkova, Petre Popescu

Abstract:

In the Astronomical Institute of the Romanian Academy (Bucharest and Cluj-Napoca observatories) there are more than 19,000 wide-field plates. Most of the plates were obtained within the framework of astrometric programmes. The plates preserve information especially valuable for analyzing of the long-term variations (sometimes more than a century) of the positions, orbits, or dimensions of a lot of celestial objects or their pre-discovery history. Archives of selected digitized plates are under preparation in order to propose on-line access to the plate information (preview images for quick plate visualization, as well as real photometric scans).

Combination of Space- and Ground-Based Astrometric Observations to Create Astrometric Catalogs

Jan Vondrak, Vojtech Stefka

Abstract:

Modern space-based astrometric observations made by Hipparcos satellite yielded two principal catalogs in optical wavelength: Hipparcos and Tycho. These catalogs, that recently celebrated ten years of existence, contain star positions with unprecedented accuracy. However, their proper motions are, due to a relatively short interval of Hipparcos mission, quite often not as good as their formal standard errors indicate. This deficiency is especially significant for about twenty percent of double or multiple stars contained in these catalogs. The combination with ground-based astrometric observations that have much longer history is therefore very important for improving the Hipparcos proper motions. Significant improvement in this respect was achieved during the past years by creating combined catalogs, such as Tycho-2, FK6, GC+HIP, TYC2+HIP, or ARIHIP. Yet a large and important group of astrometric observations of latitude/universal time variations, made in the programs of monitoring Earth orientation, stood apart from these activities. Recently we started to use these observations, covering almost the whole 20th century, to create astrometric catalogs EOC-1, EOC-2, EOC-3 and most recently EOC-4. To construct them, we used the Earth orientation observations in combination with the above mentioned catalogs. The latter two, EOC-3 and EOC-4, contain not only the "classical" linear proper motions, but also periodic changes due to orbital motions, for a substantial portion of the observed stars.

Stability and Chaos in N-Body Problems

Zhihong Jeff Xia

Abstract:
We will discuss various chaotic phenomena in the Newtonian N-body problem. In particular, we will address the following questions: What is chaos? Is the solar system stable? Can we put any good use to chaos?

SYMPOSIUM 3

Dynamics of Solar Atmosphere and Heliosphere

Convener:

Cristiana Dumitrache

Recent Progress in the Study of Oscillations in Coronal Structures

Jose Luis Ballester

Abstract:

During last years, ground- and space-based observations have provided with strong evidence about the presence of oscillations in coronal structures such as loops and prominences. In this contribution, I will present some recent developments about the oscillatory behaviour of two inhomogeneous loops; the oscillatory behaviour of a multi-stranded coronal loop; the theoretical modelling of prominence oscillations observed by HINODE, and the damping by resonant absorption of oscillations in prominence fibrils.

A Comparison of the Acoustic Hardness of an Acoustically Active and an Acoustically Non-Active Solar Flare

Diana Besliu-Ionescu, Alina-Catalina Donea, Paul Cally, Charles Lindsey

Abstract:

Recent corrections to some of the GONG B intensity images of flares allow us to image the acoustic power of white-light flare signatures. The images clearly show compact region of acoustic intensity at 6 mHz, which are spatially well correlated with the seismic signatures of the flares, if the flare proved to be acoustically active. It has been a puzzle why some of the white-light flares, mainly very strong flares, did not induce any seismic waves into the photosphere. We believe that a comparison of the white-light hardness between two flares seismically active and non-active is the clue to answer why some flares produce sunquakes and mostly of them no.

Conditions for the Formation of CMEs Associated with Filament Eruptions

Irina Bilenko

Abstract:

There are two classes of coronal mass ejections (CMEs): CMEs associated with active region magnetic activity and CMEs associated with filament eruption. They have different parameters, evolution, and structure. The relationship between filament eruptions and CMEs has been well established. But the trigger mechanism as well as the overall association between filament eruption and CME is not well understood. Space-based observatories have provided a great deal of information on the initiation and evolution of CMEs. Observations obtained with SOHO, TRACE, and Yohkoh instruments combined with data from other space- and ground-based observatories are used to study the photospheric magnetic field evolution and coronal structure changes associated with the filament eruptions and CMEs. Some filaments do not show a linear rising motion. Their evolution and eruption is characterized by different stages, during which the initial filament structure and magnetic configuration change greatly. The mechanisms leading to energy release is discussed. Sometimes filament and observed CME are widely separated in position angle. This means that the motion of a filament in

the corona is not strictly radial. The evidences are found that in some cases filament eruption may be initiated by magnetic field evolution in a remote active region. In such a case, the movement of an erupted filament would be non-radial and it may be the explanation of the spatial discrepancy between filament locations and CMEs.

Multiwavelengths Study of the Active Region 09778

Iulia Chifu, Oana Chiricuta, Cristiana Dumitrache

Abstract:

In this work we have studied the evolution and decay of the active region 09778, observed between 8 and 19 January 2001. We used data from LASCO, BBSO, Mauna Loa, and we analyzed the evolution in different wavelengths. This region produced few flares. We have analyzed the 3D coronal magnetic field evolution in search of the magnetic reconnections extrapolated from MDI/SOHO magnetograms. Below this active region a filament displayed plasma movement in connection with the region dynamics.

Polar Filament Evolution

Diana Rodica Constantin, Cristiana Dumitrache, Constantin Oprea, Marilena Mierla

Abstract:

A huge polar filament was observed between 28 December 2000 and 7 January 2001. We have analyzed its dynamics, variation of the length, title angle (for chirality's) and their correlation with the differential rotation variation. A very interesting aspect in this filament evolution is a CME occurring after a mild helical up-warded movement of plasma on 7 January, but after the filament was on far side. There are not neighbouring active regions as deduced from MDI observations; therefore we have studied at high-scale magnetic field using the method of 3D magnetic field.

Contributions to the Sun-Heliosphere Studies Using SOHO and Ulysses Data

Cristiana Dumitrache

Abstract:

CMEs are one of the most amazing solar phenomena with deep implications in terrestrial life, too. Our project covers the follow up of a CME from the solar source to the interplanetary space, using ESA missions. Our research focuses on active regions evolution and magnetic field extrapolation in 3D to reveal magnetic reconnections responsible for flares and other phenomena. Large scale magnetic reconnections are frequently responsible for the filaments destabilization and CMEs onset. Huge polar prominences or complex filaments appearing near the solar maximum and the period of polarity changes often end in spectacular CMEs. SOHO and ground based multiwavelengths observations gain us understand of these phenomena. Another objective of our research is the link between the solar sources of CMEs and the ICMEs registered by Ulysses. The track back of the ICMEs to the Sun constitutes in a challenge and we tried to make connections between the phenomena registered by SOHO and Ulysses during the solar maximum northern polar passage.

Predicting the Onset of Solar Eruptions

Terry G. Forbes

Abstract:

Large solar eruptions, including those which produce coronal mass ejections, are most likely the result of a rapid release of magnetic energy, which has been previously stored in the corona. A primary puzzle regarding such a process is the identity of the mechanism that triggers the energy release and initiates the eruption. One possibility is the onset of an ideal-MHD instability or, more generally, a sudden loss of an ideal-MHD equilibrium. A mechanism of this type would easily account for the fact that large eruptions typically occur on the Alfven timescale in the corona. Another possibility is the onset of a resistive instability that involves magnetic reconnection, for example, the tearing mode. Models of both types have recently been developed, as well as hybrid models that involve ideal and resistive processes acting in tandem.

Physics of the Solar Chromosphere

Petr Heinzel

Abstract:

We present an overview of our current knowledge of the chromospheric structure and dynamics. New models have been designed using high-quality data from space missions (SOHO, TRACE, Hinode), as well as from large ground-based facilities. Our new approaches are directed to understanding the 3D and time-dependent behaviour of highly structured and dynamical chromosphere and we will show new observational constraints for radiation-hydrodynamical modelling. Solar-stellar connections will be also briefly mentioned.

On the Origin of Turbulent Fields in Interplanetary Plasmas

Marian Lazar, Reinhard Schlickeiser

Abstract:

Solar coronal mass ejections are one prominent example of interpenetrating particle streams of different properties: densities, speeds, temperature, composition, etc. Such counterstreaming plasmas are quickly unstable leading to the excitation of purely growing instabilities of filamentation or Weibel type. Here it is demonstrated that these instabilities and their cumulative effect provide a plausible mechanism for the origin of two-dimensional magnetic field fluctuations in interplanetary medium.

Linear Incompressible MHD Waves in Periodic Magnetic Solar Structures

Alexandru Marcu, Gabriela Mocanu, Beniamin Orza

Abstract:
The spatial structuring of solar and space plasmas is known to have a dispersive effect on waves. Many solar features possess a periodic structure having alternating properties. Here the effect of periodic alternation of magnetic slabs on wave propagation is studied using the Bendickson and Dowling model. The dispersion relation and criteria for the appearance of standing waves is derived and analyzed by taking into account the spatial scaling of the system and the strength of magnetic field. It is shown that for narrow frequency bands of the incident waves there is a correlation between observed standing waves and number of medium slabs.

Observing, Modelling and Predicting the Effects of Solar Radio Bursts on Radio Communications

Mauro Messerotti

Abstract:
The Sun is a source of broadband radio noise, which can reach significantly high levels during outbursts associated with the time evolution of the activity cycle. The statistics point out that the maximum occurrence frequency and intensity of solar radio bursts (SRBs) are observed in the proximity of the activity maximum, but relevant phenomena can occur also in the raising and declining phases of the cycle. Both theoretical estimations based on extensive statistical analyses carried out in recent years and direct observations performed in the past solar activity cycle indicate that solar radio bursts can interfere wireless communications as well as Global Navigation Satellite Systems. In this work, we briefly review the theoretical basis and the experimental evidences to date and we show the effectiveness of fast multichannel solar radiopolarimeters, like the Trieste Solar Radio System, in monitoring and predicting solar radio noise increase in the framework of Space Weather applications.

Mass Estimates and Wave Propagation for the Eruptive Event of 8 January 2002

Marilena Mierla, Adrian Sabin Popescu

Abstract:
It is still not well known what role prominences play in the initiation and evolution of coronal mass ejections. A part of this study consists in estimating the prominence mass, using EIT data. The method, applied on the eruptive event on 8th of January 2002, is based on the ratio of the eruptive prominence mass to the mass of the quiescent corona. In this way we can observe whether the mass was added or lost during the eruption. The other purpose of this study is to determine the general properties that must be fulfilled in

the corona for the EIT wave propagation. The local magnetic field density will be used, in a qualitative way, to estimate the amplitude and the velocity of the EIT wave.

Effects of Large Solar Events on Atmospheric Drag of Earth Artificial Satellites

Liviu Mircea

Abstract:
Sharp bursts of solar activity, in the form of highly energetic radiation (extreme UV and X-rays), mass transfers (coronal mass ejections) and energetic charged particles (electrons, protons and ions), act on the upper atmosphere of the Earth, and change its state parameters (temperature, structure-altitude distribution, chemical composition and density) and also interact with the Earth's magnetic field. Each of these physical processes creates Joule effects which puff up the Earth's atmosphere. This solar outputs increase dramatically during cyclic periods of intensive solar activity or due to irregular major storm events. These are causing high temporary correlation with the above mentioned state parameters perturbations, inducing thermospheric expansion and density increasing, generating atmospheric brake of terrestrial artificial satellites, reducing their orbital lifetime and requiring thrust maneuvers to maintain them at proper altitudes. Physical meaning of the presence of atmospheric drag variation is the rate of the "mean motion" change (variation of the orbital revolutions numbers per day) and the variation of perigee altitude, which both characterize the rate of loss in potential energy of the satellite. In this contribution we are taking into account the variations of orbital parameters of artificial satellites revolving at thermospheric altitudes and are object of different solar-terrestrial interactions.

The Measure of the Solar Rotation

Zadig Mouradian

Abstract:
After a short historical introduction, we shall give the characteristics for the rotation of the solar atmosphere. I will describe the three basic methods used for the measure of the solar rotation rate: the spectroscopic method, the tracer's method, and the new global method. For each one we will comment on the method, its main properties and advantages, and show its field of application. Then we conclude with considerations on the rotation of solar interior.

A CME-ICME Event Analysis

Adrian Oncica, Nedelia Antonia Popescu, Cristiana Dumitrache

Abstract:
Our study focuses on the onset of spectacular CMEs 'en raffale' observed by SOHO and also on the possible corresponding ICME event registered by Ulysses. A huge filament

erupted two times on 15 August 2001. Part of the mass ejections propagated toward Ulysses. An important ICME was registered on 19 August 2001.

Solar Flares of Different Types and their Influence on Formation of Interplanetary Medium Disturbances

Aleksei Osokin, Moissei Livshits

Abstract:

Reasons for statistical relation observed between duration of nonstationary processes on the Sun and power of disturbances relevant in the interplanetary medium are studied. Homogeneous data on soft X-ray radiation of more than 50,000 flares make it possible to study their number distribution with duration for four ranges of event powers. Three event types are separated, namely, impulse flares of the total duration less than 30 minutes, typical (two-ribbon) flares of less than 1-2 hours in duration, and very long-term events including in phenomena in activity complexes and dynamical flares. These results are in good agreement with expected phenomena durations determined from the energy balance in the flare source of the soft X-ray radiation. In particular, free leaking of hot plasma generated takes place in impulse flares, while heating near a coronal-loop top is significant in two-ribbon flares and determines a whole process in prolonged flares. Comparison between data on soft and hard X-rays demonstrated rather powerful impulses are followed as a rule by formation of a coronal loop system. In an impulse phase of these typical flares, upward plasma flows appear near each footpoint with the increase of the total event duration resulting in CMEs and subsequent disturbance of the interplanetary medium. In the most prolonged flares, CMEs often give rise new flares formation, the ejection of substance from coronal levels continuing and increasing the CMEs and disturbances in the interplanetary space for a long time.

Numerical Simulations of the Initiation and the IP Evolution of Coronal Mass Ejections

Stefaan Poedts

Abstract:

Coronal Mass Ejections (CMEs) belong to the most violent and fascinating events in the solar system. These events involve large-scale changes in the coronal structure and significant disturbances in the solar wind. Especially the massive, fast CMEs are interesting to study as these events cause shocks that propagate through the interplanetary (IP) space. In these IP shock waves energetic particles continuously accelerate giving rise to gradual solar energetic particle events (SEPs). As a result, CMEs and the CME generated shock waves play a key role in the so-called space weather. Better mathematical models of the solar corona and of CME initiation events and IP CME evolution are required. We present recent results from numerical simulations of the initiation and IP evolution of CMEs in the framework of ideal magnetohydrodynamics (MHD). As a first step, the magnetic field in the lower corona and the background solar wind are reconstructed. Both simple, axi-symmetric (2.5D) solar wind models for the quiet sun as well as more complicated 3D solar wind models taking into account the actual coronal field through magnetogram data are reconstructed. In a second step, fast CME events are mimicked by superposing high-density plasma blobs on the background wind and launching them in a given direction at a certain speed. In this way, the evolution of the CME can be modeled and its effects on the coronal field and background solar wind studied. In addition, more realistic CME onset models have been developed to investigate the possible role of magnetic foot point shearing and magnetic flux emergence/disappearance as triggering mechanisms of the instability. Parameter studies of such onset models reveal the importance of the background wind model that is used and of the initiation parameters, such as the amount and the rate of the magnetic flux emergence or the region and the amount of foot point shearing.

Models for Heavy Tailed Data and Applications

Emil Popescu, Nedelia Antonia Popescu

Abstract:

An important topic in space research is represented by the study of statistical properties of the interplanetary magnetic field fluctuations, these being closely related to acceleration processes and energy transport in the solar wind. Analysis of the probability density functions of the velocity and magnetic field fluctuations has underlined their non-Gaussian properties on small time scales, and uncorrelated features at large scale. In this paper, numerical solutions of space-time fractional diffusion equations are used to analyze the presence or absence of heavy tails typically associated with multiscale behavior, in the case of the interplanetary magnetic field data obtained by Ulysses mission.

Role of Small and Large Scale Magnetic Fields in Filament Eruption

Brigitte Schmieder, Tibor Toeroek, Guillaume Aulanier

Abstract:

Solar filaments (or prominences) can be represented by twisted flux ropes in a bipolar magnetic environment. In such models, the dipped field lines of the flux rope carry the filament material and parasitic polarities in the filament channel are responsible for the existence of the lateral feet of prominences. We first argue that any change of minor polarities, as for example the cancellation of magnetic flux and the decrease of the strength of the magnetic background field, can be responsible for filament eruptions. We then present observations of large-scale changes of the magnetic field in the vicinity of filaments (divergence flows, shear, differential rotation) and discuss their role in filament eruptions. We finally focus on emerging flux within or in the vicinity of filament channels. For a particular event, observed with HINODE/XRT we find signatures of magnetic reconnection between the emerging flux and the pre-existing coronal field, but no eruption of the filament. We present numerical MHD simulations which show for the first time for a realistic 3D coronal flux rope model that emerging flux can trigger eruptions, but only if the changes in the coronal magnetic field due to the reconnection between the emerging and the pre-existing flux are sufficiently strong to allow the flux rope to become unstable and erupt. Based on the simulation results, we

suggest the main physical parameters, which decide whether emerging flux in the vicinity of a filament channel leads to the eruption of the filament or not.

Realistic Three-Dimensional Numerical Simulation of Solar Local Supergranulation

Sergey Ustyugov

Abstract:

I present results of three-dimensional numerical simulation of solar surface convection on scales of local supergranulation with realistic physical models. I study the thermal structure of convective motions in photosphere, the range of convection cell sizes and the penetration depths of convection. A portion of the solar photosphere extending horizontally on 100 x 100 Mm and from 0 Mm down to 20 Mm below the visible surface is considered. I take the equation of state and opacities of stellar matter and distribution with radius of all physical variables from the Solar Standard Model. The equations of fully compressible radiation hydrodynamics with dynamical viscosity and gravity are solved. The high-order conservative PPML difference scheme for the hydrodynamics, the method of characteristic for the radiative transfer and dynamical viscosity from subgrid scale modeling are applied. The simulations are conducted on a uniform horizontal grid of 1000 x 1000, with 168 nonuniformly spaced vertical grid points, on 228 processors with distributed memory multiprocessors on a supercomputer MVS5000 in the Computational Centre of the Russian Academy of Sciences.

SYMPOSIUM 4

Stellar Astrophysics, Extragalactic Astronomy, and Cosmology

Conveners:

Nedelia Antonia Popescu

Marian Doru Suran

Alexandru Dumitrescu

Ultra High Photometry from Space - First Results

Annie Baglin

Abstract:

After a few preliminary missions as MOST and WIRE, CoRoT is now delivering very accurate photometric data over long continuous periods of time, on a very large number of stars. Many subjects are questioned by these data. First evidently the discovery of transiting planets will enlarge considerably the statistics and contribute significantly to the validation or not of formation theories. Then unexpected seismology behaviors face difficulties to be interpreted, showing the variety of stellar properties. Topics like activity and rotation start to be seriously unveiled with the accuracy of CoRoT. Eclipsing binaries are also widely represented. The success of CoRoT allows to prepare second generation missions with confidence. Some of them will be described.

Environmental Effects on Galaxies in Clusters

Chantal Balkowski

Abstract:

Galaxies in clusters are affected by their environment. I will present examples of multiwavelength observations of spiral galaxies in the Virgo cluster and a comparison with simulations in order to date the stripping event and to understand the past history of the galaxies after they enter into the cluster.

Extragalactic Globular Clusters: Tracers of Galaxy Evolution

Lilia P. Bassino

Abstract:

The study of globular cluster systems (GCSs) provides clues about different topics related to galaxy evolution. In the past years we have been investigating the GCSs of galaxies in the Fornax and Antlia clusters, particularly those associated to the cluster-dominant galaxies.We present here the main results related to these GCS properties. All of them have bimodal colour distributions, even those around low-luminosity galaxies that correspond to the metal-poor (“blue”) and metal-rich (“red”) globular cluster (GC) subpopulations. The radial and azimuthal projected areal distributions of the GCs are also analysed. Total GC populations are estimated through the luminosity functions. We stress on the properties of the GCSs that allow us to trace possible interaction processes between the galaxies, like tidal stripping of GCs. The observational material consists of CCD images obtained with the wide-field MOSAIC Imager of the CTIO 4-m telescope (La Serena, Chile), and the FORS1 camera at the VLT “Antu” 8-m telescope (Cerro Paranal, Chile).

Exo-Planets Transits: Orbit and Mass Estimations

Alexandru Dumitrescu, Marian Doru Suran, Stefan Gabriel Sorescu

Abstract:

The modern astrophysical techniques allowed the observation of the exo-planets transits. The high accuracy photometric and spectroscopic observations provide substantial information about the exo-planetary system. The observational data consist of the photometric light curve generated by the planet transit and the radial velocity curve of the central star. The interpretation of these curves makes possible the estimation of some parameters as: mass ratio, separation, orbit inclination, radius of the central star. We present different interpretation methods depending on the available observational data.

The First Ground-Based Observations of the Eclipsing Binary V449 Aur Made at Bucharest Observatory

Alexandru Dumitrescu, Marian Doru Suran, Stefan Gabriel Sorescu

Abstract:

The binary system V449 Aur was observed in Bucharest Observatory using the 50-cm telescope. The light curve and the preliminary elements are presented.

Looking into B Star Interiors by means of Asteroseismology

Wojciech Dziembowski

Abstract:

Precise modelling of upper main sequence stars is important for a quantitative description of massive star evolution, up to the end as white dwarfs or supernovae, and chemical evolution of galaxies. However, there are still significant uncertainties resulting mostly, but not only, from our poor understanding of transport processes. Data on pulsating objects, in particular on beta Cephei stars, provide us valuable constraints on parameters describing efficiency of these processes and assess the overall accuracy of present stellar models. After a brief survey of properties of main sequence B star pulsation, I will review ways of extracting information on stellar interior structure and rotation from pulsation data and present results for selected objects.

Stark Broadening of O V 1371 A Line in Stellar Atmospheres

Milan S. Dimitrijevic, Andjelka Kovacevic, Zoran Simic, Miodrag Dacic

Abstract:

The Stark broadening of O V 1371 A spectral line observed in stellar atmospheres of hot stars is considered. The corresponding Stark broadening parameters were

determined within the semiclassical method. We found that Stark broadening mechanism is very important in atmospheres of hot stars like DO white dwarfs and should be taken into account.

Electron-Impact Broadening of Ar I 737.212 nm Spectral Line for Stellar Atmospheres Research

Milan S. Dimitrijevic, Magdalena Christova, Zoran Simic, Sylvie Sahal-Brechot

Abstract:

With the development of space-born spectroscopy, the importance of atomic data, including the Stark broadening parameters, for trace elements like argon, increases. For example argon is found in CVn binary σ^2 Coronae Borealis, and recently, argon lines are observed in the optical spectrum of the Be star Hen 2-90. Also argon abundance has been determined from spectral lines, e.g. for LSE 78, an extreme helium star, for the similar star BD-9-4395, for DY Cen and γ Peg. Consequently, electron-impact (Stark) line-broadening parameters for neutral and ionized argon are of interest for the modelling and investigation of astrophysical plasmas. Here are determined needed Stark broadening parameters (width and shift) for Ar I 737.212 nm spectral lines on the basis of the impact theory within the semi-classical perturbation approach.

The Beta Cephei Type Variable Star BW Vulpeculae

Ladislau Farkas

Abstract:

The observations, light curves and preliminary elements for this star are presented.

LITTLE THINGS Survey - A Quest to Understand Dwarf Galaxies

Dana Ficut-Vicas

Abstract:

Presently, an international team of researchers is undertaking a knowledge odyssey into the subject of dwarf galaxies: the LITTLE (Local Irregulars That Trace Luminosity Extremes) THINGS (The HI Nearby Galaxy Survey) project. Although dwarfs are the most common type of galaxies, some of their charms are still kept away from our understanding: why is the star formation so different in small galaxies than in spiral galaxies; how do giant cloud complexes and stars form at all in sub-threshold gas. The project was granted VLA (Very Large Array) observing time (376 hours in B, C and D arrays) to obtain maps in the 21-cm line of neutral hydrogen (HI) able to show clouds, shells and turbulent structures important for star formation as well as extended, low-density gas around the star formation regions. The radio data will be combined with optical data (Halpha images) and GALEX data (UV images) for tracing star formation in the inner, as well as the outer parts of the galaxies. The LITTLE THINGS Survey is the attempt to shed some light on the star formation mechanisms in dwarf galaxies, to

provide missing links in our understanding of galaxy evolution and, by studying their kinematics, to address the Dark Matter problem.

Constructing Exact Solutions for Special Cases of Einstein Equations in Vacuum

Vladimir S. Gerdjikov

Abstract:

We analyze and construct soliton solutions for a class of Einstein equations in vacuum whose metric tensor depends on only two variables. These equations allow Lax representation. Therefore it is possible to derive explicitly their soliton solutions using the dressing Zakharov-Shabat method.

Measurements of Stellar Structure through Asteroseismology

Hans Kjeldsen

Abstract:

Asteroseismology (using stellar oscillations to study the interior of stars) is a relatively new and growing research field in astrophysics. Recent developments have led to a breakthrough in our study of the details of cores of solar-like stars and it is foreseen that a number of key science questions will be addressed through the analysis of frequencies and other properties of stellar oscillations. Oscillations are found in stars of most masses and essentially all stages of evolution. Their frequencies are determined by the internal sound-speed and density structure of the stars, as well as rotation, convection processes and possibly effects of magnetic fields. In this talk I will present some of the latest results from asteroseismology of solar-like stars, including the analysis of oscillation frequencies in alpha Centauri A and B, beta Hydri and Procyon. I will also describe how we may use the data from the CoRoT, Kepler and SONG projects to do detailed studies of stellar structure and evolution in the near future.

On the Magnetic Fields in Active Giants

Renada Konstantinova-Antova, Michel Auriere, Remi Cabanac, Pascal Petit, Jean-Francois Donati, Svetlana Boeva, Alexander Antov, B. Spassov

Abstract:

Direct detection of the magnetic field longitudinal component in single active giants was carried out in the framework of the Bulgarian-French collaboration. The spectropolarimeter NARVAL and the 2-m telescope at Pic du Midi were used. First results and possibilities for a larger study on this topic are discussed.

Pulsational Stability of Rotating Stars

Umin Lee

Abstract:

I revisit the problem of pulsational stability of low frequency g modes of rotating stars. The effects of rotation on the pulsational stability are attributed to the Coriolis force and the centrifugal force. Although the Coriolis force does not affect the equilibrium structure of rotating stars, the centrifugal force does have appreciable effects on the equilibrium structure and hence their evolution. As suggested by Walker et al (2005), low frequency retrograde g modes of rapidly rotating Be stars are stabilized by the effects of rapid rotation, and it is useful to find how such a strong and selective stabilization effect occurs to low frequency modes. I examine the pulsational stability of low frequency g modes by taking account the effects of both the Coriolis and the centrifugal forces, where the rotational (spherical) expansion is included when calculating the equilibrium models and the effects of the Coriolis force and the rotational deformation are considered in the pulsational stability analysis, that is, nonadiabatic oscillation calculation.

Stellar and Exoplanetary Astrophysics in the Era of Spacebased Ultraprecise Photometry

Jaymie Mark Matthews

Abstract:

When we meet in Bucharest, we will be celebrating the centenary of the Bucharest Observatory. The half-centenary of the space age of humanity will have been marked less than a year before. In the past fifty years, orbiting observatories have opened our eyes to unexpected phenomena in astrophysics by opening windows on new wavelength ranges. Recently, a new generation of photometric satellite missions has also widened our vision. Not by opening our eyes wider, but rather by allowing us to keep our telescopic eyes open longer and to be more sensitive to subtle changes in the flux of starlight that reaches them. These spacebased pioneers are providing new challenges and perspectives on Sun-like stars, which complement the studies of our own Sun by solar astronomers like those at the Bucharest Observatory. What are we learning from missions like WIRE, MOST and CoRoT and what can we expect to learn from Kepler? I will show how extended continuous time coverage and unprecendented photometric precision from space have had exciting impacts across the entire HR Diagram. Acoustic oscillations (p-modes) in solar-type stars, red giants, pre-main-sequence stars, and magnetic chemically peculiar stars mean that asteroseismology can probe the entire life cycle of a star. The g-modes of massive stars and possible strange modes (or lack thereof) in Wolf-Rayet stars are testing models of supernova precursors, and shedding light on whether light alone (radiation pressure) can account in some cases for the dense high-velocity WR winds. We are now able to measure the surface rotation profiles of young active solar-type stars and the cloud properties of giant exoplanets. We can search for exoEarths. And all this has been possible in less than a decade. The next decade holds tremendous promise. Even the few months between the time at which I'm writing this abstract and when I will give the talk in Bucharest will add new discoveries to the list above. I usually talk too much, but for this talk, I think it will be justified.

CoRot, a New Insight on the Field of Stellar Oscillations

Eric Michel

Abstract:
More than one year after its launch, CoRoT is carrying on its observational programme, building up a unique set of rapid photometry data on a significant sample of pulsating stars. This material will shed a new light on this wide exciting field of research. We will discuss some of the first new elements raised by these observations.

Non-Archimedean Cosmology

Zarko Mijajlovic, Nadezda Pejovic

Abstract:
We shall try in this contribution to apply non-standard analysis in cosmology. In the suggested non-standard cosmological model we describe infinite distance, time intervals and masses appearing in cosmological scales. In particular, we shall discuss the non-Archimedean structure of Minkowski space-time and models with infinitely large number of particles. Similar investigations were performed by V.S Vladimirov, A. Yu. Khrennikov, B. Dragovic and their followers, but by use of p-adic numbers, see for example, *p-adic Mathematical Physics*, AIP Conf. Proc. 826. Our approach is based on non-standard analysis, in particular by use of saturated structures.

Phemu 2003 Campaign - CCD Observations Made at Cluj-Napoca Astronomical Observatory

Dan Moldovan

Abstract:
The CCD-observations of mutual events (occultations and eclipses) in the system of Galilean satellites of Jupiter have been carried out in the period of November 2002 to Mars 2003 at Cluj-Napoca Astronomical Observatory using MEADE 16" LX200 optical instrument and a CCD Meade Pictor 416 camera. The observations were carried out corresponding to the ephemerides of mutual events calculated by J.-E. Arlot (2002, A&A, 383, 719-723). 30 photometric observations for 17 occultations and 13 eclipses have been performed. The data we are using were processed and reduced with AIP4Win2.0 software by V. Turcu (Cluj-Napoca Astronomical Observatory). The moments of time were fixed in the time scale UTC, and the accuracy of registration is 0.5 s. The Gaussian models and cubic spline functions were used to aproximate the light curves. The results are given in tables and graphics.

Our Galactic Neighbourhood - a Melting Pot of Migration

Birgitta Nordstrom

Abstract:

Spiral galaxies are an important part of the visible Universe. In the prototype, our own Milky Way, can we observe the most important component of a spiral galaxy, the disk, in unprecedented detail. In the Solar neighbourhood we can determine the numbers, ages, detailed chemical compositions, and galactic orbits of stars from the entire history of the disk with a completeness and accuracy not available anywhere else in the Universe. Therefore, the solar neighbourhood is a fundamental benchmark for all models of the evolution of galaxy disks. The Geneva-Copenhagen Survey (Nordstrom et al. 2004) has full spatial, kinematic, metallicity and age information for 14,000 long-lived stars and provides a rich source of data for tests of models of evolution and formation of the Galaxy. We find that classical evolution models for the Galactic disk fail several of the standard tests related to the stellar metallicity distribution, age-metallicity relation, and age-velocity relation. The classical evolution paradigm of gradual enrichment and dynamical heating of galaxy disks with time will be discussed (Holmberg, Nordstrom, Andersen 2007; Seabroke and Gilmore 2007). Both dynamical and kinematic evolution need to be taken into account in sufficient detail by the models to match the best data. A search for signatures of past accretion events in the Milky Way (Helmi et al. 2006) has yielded evidence of ancient substructure in the Galactic Disk.

Star Formation and Evolution of Galaxies

Jan Palous

Abstract:

This review discusses how the star formation influences the evolution of galaxies. Processes in the ISM combine the gravitational instability with hydrodynamical instabilities triggering formation of stars. Various feedback processes operating in star forming regions such as stellar winds, ionizing radiation and supernova explosions will be mentioned. The bubbles of hot gas containing the yields from stellar evolution surrounded by expanding shells compose the complex structure of the ISM. The hydrodynamics of winds of super star clusters and formation of galactic winds blowing to large distances from parent galaxies will be discussed. The star formation in the early Universe distributing the metals into first galaxies will also be mentioned.

Y Leonis Reloaded

Alexandru Pop, Vlad Turcu, Alexandru Marcu

Abstract:

The aim of the present contribution is to stimulate the interest in observational and theoretical study of the Algol-type binary system Y Leonis. Different arguments are presented from both the viewpoint of stellar photometry and orbital period variability.

The problem of the influence of the possible activity cycle of the secondary component on the orbital period is also approached.

Detection and Diagnosis of Low-Level Stellar Variability in Nonevenly Spaced Data

Alexandru Pop, Calin Vamos

Abstract:

An important goal of astronomical time series analysis is the detection of low-level stellar variability. The next step is the diagnosis of the detected variability, i.e. one have to discriminate among the specific contributions of noise, periodicity, or more complex variability phenomena. The preliminary results of our investigations on simulated time series with nonevenly sampling using Monte Carlo type methods are presented.

RT Andromedae: Period Variation Revised

Alexandru Pop, Rodica Roman

Abstract:

In a previous paper on the orbital period variability of RT Andromedae we found strong evidences for the presence of a 29.4 years periodicity in its O - C curve. We also found other two shorter possible periodicities: 9.56 and 5.86 years. A recent photometric study of RT And concluded that the stellar activity cycle in this binary may have a periodicity of 6.69 years. This value is close to the shortest periodicity emphasized by us from timing data. The aim of the present study is to reanalyze the timing data available at this moment in order to investigate the possible relation between the orbital period modulation and the activity cycle of RT And.

The Centenary of Blazhko Effect

Vasile Pop

Abstract:

The Blazhko effect is a periodic amplitude and/or phase modulation of the light curve with a timescale of about five to hundreds of days (Jurcsik et al. 2006, arXiv: astro-ph 0603496v1) in many types of pulsating stars in different stages of their evolution. This phenomenon was first detected in the important class of RR Lyrae stars by the Russian astronomer Sergey Nikolaevich Blazhko (1870-1956). A century ago Blazhko (1907, Astron. Nachr. 173, 325) was the first to report this phenomenon in the RR Lyrae star RW Dra, now known as the Blazhko effect. It was almost a decade later that Shapley (1916, Ap. J. 43, 217) found that the amplitude and light curve shape of RR Lyrae itself changed with a 41-day secondary period. More than 90% of the known globular cluster variables are RR Lyrae stars. The incidence rate of Blazhko variables among the RRab (RR0) stars is about 20-40% and for the RRc (RR1) Blazhko stars this rate is less than 5% (Moskalik and Poretti, 2003, A&A 398, 213). Period changes, too fast to be of evolutionary nature, are also reported in RRab Blazhko stars. Some field Blazhko stars (RR Lyr, XZ Cyg, RW Dra, etc.) are reported to display, beside their Blazhko cycles, also very long cycles, of the order of years, which remind us of the solar activity cycle (Szeidl, 1988, in Multimode Stellar Pulsations, p. 45; Pop, 1978, Studia Univ. Babes-Bolyai, Math., 1, 21). Recently Goransky and Barsukova (2007, Astronomer's Telegram No. 1120) shows that the V79 in the globular cluster Messier 3 was known as RRab type star with the period of about 0.483 days during the century after its discovery by Bailey in 1895, but, in April 1992, the switch of mode occurred and the first overtone with the period of 0.359 days became the dominant mode. The June 2007 CCD observations show that V79 passes through the reverse switch from dominant first overtone to fundamental mode with period 0.4825 days. The light curve is typical for an RRab star with the amplitude of 1.2 mag, and shows a pronounced amplitude modulation with an unusually small period of about 1.389 days. This phenomenon was unprecedented for the class of RR Lyrae stars. There is no accepted explanation of the origin of the Blazhko effect, although it has been suggested that it could be caused by mixing of pulsation modes or magnetic cycles. All viable models for this phenomenon assume the presence of nonradial component. Chandid et al (1999, A&A 352, 201), Kolenberg (2000, ASP Conference Series, Vol 203, 286), using spectroscopic data spread poorly over the Blazhko cycle, claimed for the first time the detection of nonradial modes in RR Lyrae itself. It is clear that we cannot claim to understand RR Lyrae pulsations without being able to explain the Blazhko effect. The "Blazhko Project" is an international collaboration that was founded in Vienna at the end of 2003 aiming at a better understanding of the physical mechanism responsible for the modulation (Kolenberg 2004, Proceedings IAU Symposium No. 244, 376). I present an overview of the status of research devoted to the Blazhko effect and the Romanian contributions are emphasized.

Knot-Based Large-Scale Structure Code

Adrian Sabin Popescu

Abstract:

In the Dimension Embedded in Unified Symmetry (D.E.U.S.) we made a qualitative description of the way in which we can construct the Large Scale Structure of the Universe from the knot-particle equivalence. Even that we are limited by the lack of computational power implemented on a nonlinear computational architecture needed to conduct this study to its finish, we are still able to give the algorithm to be used in a future simulation, on a, let say, quantum computer.

Dust in Galaxies

Cristina Carmen Popescu

Abstract:

Here I will review recent observational and theoretical work that has advanced our understanding of dust in galaxies and discuss its implication for the field of galaxy formation and evolution.

Galaxy Pairs and Groups in the AGNs' Environments

Nedelia Antonia Popescu

Abstract:

Combining optical-NIR photometrical data and HST/WFPC2 morphological data for galaxies in the environments of four AGN at z~1, we carry out a morphological, photometrical and dynamical study of elliptical galaxies and disk galaxies properties, at different stages of interaction. The goal of this study is to analyze the properties of galaxy pairs and groups with respect to their parent sample, and to analyze the interaction effects (mergers, "dry mergers") on color and morphology of galaxy pairs, especially for disk galaxy pairs and mixed morphology pairs.

Probing the Physics and Kinematics of AGN Emitting Regions Using Line Shapes

Luka C. Popovic

Abstract:

The narrow and broad emission lines are present in spectra of Active Galactic Nuclei (AGN). Their shapes and intensities give us opportunity to investigate the physical and kinematical properties in the central part of AGN. Narrow emission lines (with widths ~ several 100 km/s) are originated in an extensive region (so-called Narrow Line Region - NLR) which can be resolved in the nearest AGNs, while broad emission lines (with widths ~ several 1000 km/s) are formed in a very compact region (so-called Broad Line Region - BLR) in the central part of AGNs. The investigation of their shapes provides information on the conditions of the emitting gas surrounding a black hole, assumed to be in the center of such objects. In this talk we will discuss the importance of the AGN spectral line shape investigations from X-ray (Fe K-alpha line) to optical wavelength band. The methods for investigation of kinematics and physics of the emitting gas in NLR and BLR using line shapes as well as the external effects that can disturb line profiles in these objects (as e.g. gravitational microlensing) will be discussed.

V477 Cygni - A Theoretical Approach of the Apsidal Motion

Rodica Roman

Abstract:

The existence of various values for the apsidal period of V477 Cygni, a lack of values for apsidal motion constants and a suspicious presence of a third body in the binary system have incited our interest for a new analysis of apsidal motion. We assumed that both components are main sequence stars. In order to determine independent values for the apsidal constants, we used the elliptical restricted three body problem. In addition we considered the tidal and rotational effects, too. The corresponding results are coupled with the classical study of apsidal motion, and a system of three equations with the unknowns: the apsidal constants and the abscissa of the first Lagrangian point are

established. Numerical computations lead to the apsidal period U = 377 years. These results are not affected by an eventual presence of a third body.

Exoplanets

Eleni Rovithis-Livaniou

Abstract:

A short review concerning the exoplanets, i.e. the planets revolving around stars other than our Sun, will be presented and discussed. More analytically: the methods used and the up to now results will be given. Besides, as during the last years the number of exoplanets has increased, we have the opportunity to compare them between, and with those of our solar system. Moreover, the now on as well as the future missions will be referred.

Modelling Pulsations of Magnetic Ap Stars

Hideyuki Saio

Abstract:

Some chemically peculiar Ap stars with strong (a few kG) magnetic fields pulsate (or oscillate) with periods much shorter than the fundamental pulsation period; i.e. they pulsate in high-order nonradial p-modes. We call them roAp (rapidly oscillating Ap) stars. So far, about thirty roAp stars are known. The coupling between a p-mode pulsation and a magnetic field shifts the pulsation frequency, damps the pulsation, and modifies the amplitude distribution significantly. I will talk about methods to calculate p-mode frequencies and eigenfunctions of a magnetic star, and some theoretical results as well as comparisons with observations.

The Seismology of the Universe - the Inverse Method in Cosmology

Marian Doru Suran

Abstract:

In the early ‘90s our cosmological team at Bucharest Observatory investigated the problem of the correlated signals in the 1D deep pencil beams (BECS) and in the long tail of the correlation functions using 3D catalogues of galaxies (LCRS), clusters of galaxies and superclusters of galaxies (North and South poles surveys). A significant signal at r = 100 h**(-1) Mpc was found. Depending on different cosmological scenarios, this signal was interpreted as a nonlinear response of the superclustering in a CHDM scenario or as a signal of the linear structure evolution in a CDM /LCDM scenario (after the discovery of the reacceleration of the Universe in 1998). Baryonic features in the correlation functions and in the corresponding power spectra represent a strong consistency test for the cosmological models. Such features are the direct results of small density fluctuations in the early Universe, prior to the recombination epoch. At these epochs the baryons were tightly coupled with photons and shared the same

pressure-induced oscillations that lead to acoustic peaks in the CMB. Theoretical descriptions isolate better the unique and robust observational signature of the physical processes in the early Universe and quantify their scaling with cosmological parameters. These also probe parameters degeneracies and suggest possible consistence tests with the related effects in CMB. Used as an inverse method, these tests allow us the determination of precise cosmological parameters values for the post-inflationary Universe, giving answers to the problems related to the formation and evolution of material structures in the radiation and matter dominated epochs, and to the behaviour of the EoS for the inflating and the reaccelerating Universe.

About the Star ε Oph

Marian Doru Suran, Dumitru Pricopi

Abstract:

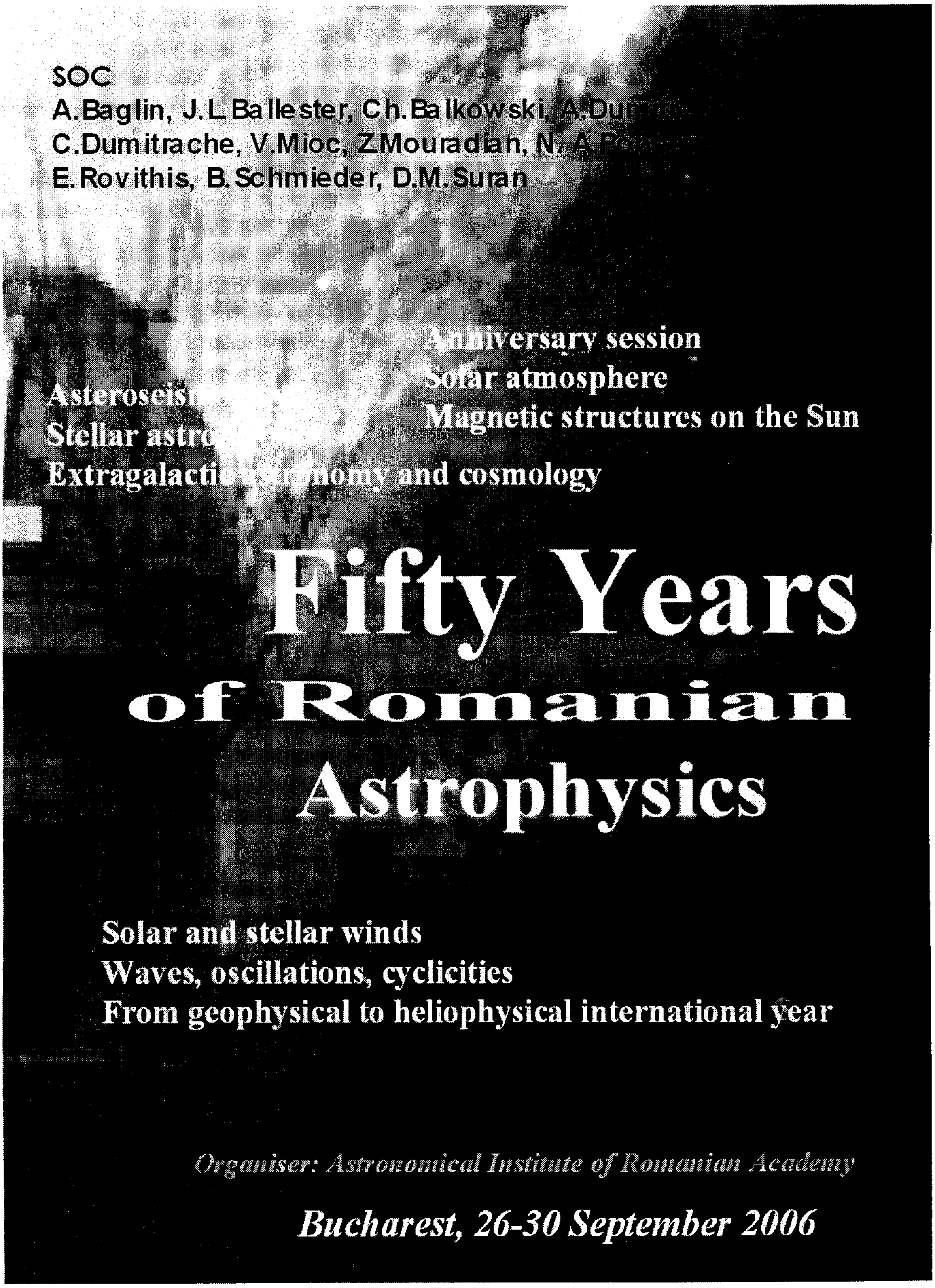
We present in this paper the results obtained for the star Epsilon Ophiuchi using the ROMOSC asteroseismological method (CESAM2k+LNAWENR) Comparisons with the similar results obtained by the MOST team are also presented.

GP Andromedae Survey Byproducts

Vlad Turcu, Alexandru Pop, Dan Moldovan

Abstract:

The Delta Scuti star GP Andromedae was observed at the Cluj-Napoca Astronomical Observatory between 2002 and 2007. During this period we obtained more than 10,000 CCD frames in 17 nights, containing five possible comparison stars. The differential photometry of these stars revealed possible long-term variability for one of them, while preliminary statistical analyses emphasize the possible microvariability in two other cases. The variability survey of these stars is approached through complementary methods. The preliminary results of our analyses are presented.



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Solar atmosphere
Magnetic structures on the Sun
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Marolf Embedding Diagrams and Gravitational Collapse

Paul Blaga

Recently, Donald Marolf considered a new kind of embedding digram for a spacetime with a black hole, in which selected 2-surfaces are embedded in the 3-dimensional Minkowski spacetime, instead of the Euclidean 3-space as it was done before. We extend this diagrams to the case of the spacetime of a relativistic star and investigate the way in which the diagrams evolve during the gravitational collapse of the star towards a black hole final state.

Families of orbits compatible with galactic potentials

Mira-Cristiana Anisiu

Given a monoparametric family of curves f(x,y)=c, the potentials V=V(x,y) under whose action a particle of unit mass can describe the curves of that family satisfy Szebehely's (1974) equation, in which the total energy of the particle appears, and Bozis' (1984) equation, relating merely the potential and the given family. Considering some models of galactic potentials, we present families of orbits that can be traced under their action. We use also the 3D equations of the inverse problem (Anisiu, 2004, Bozis and Kotoulas, 2004) to study similar problems.

On the flux ratio of [OIII] 5007, 4559 A lines in AGNs

M.S. Dimitrijevic, J. Kovacevic, L. C. Popovic, E. Bon, and M. Dacic

Up to now, all direct observational checks of the theoretical [OIII] 5006.843/4958.911 intensity ratio have been made for planetary nebulae spectra. However, we will give several examples that, in some papers analyzing spectra of quasars, galaxies and AGN's, this ratio is obtained as by-product, used as a checking method or may be derived from published results. Recently, taking into account relativistic corrections to the magnetic dipole operator, Storey and Zeippen obtained the line intensity ratio of 2.98. In order to check that new value using the AGNs spectra, we present here the measurements of the [OIII] 5007, 4959 A flux ratios for the sample of 30 AGNs. We selected our sample of AGNs from the "Date Release Four" (DR4) of SDSS Database and from the published observations. Our selection criterion was that relation S/N is high. Also, we compared the shapes of 4959A and 5007A lines, and selected only those AGNs were these lines may be scaled to the same shape. Our preliminary result for flux ratio is 3.00 +- 0.14. This is very close to the theoretical value of Storey and Zeippen..

Non-Archimedean Methods in Cosmology

Zarko Mijajlovic, Nadezda Pejovic

The classical study of Standard Cosmological Model (SCM) is based on the mathematics over R, the field of real numbers, or C, the field of complex numbers. Both these structures are archimedean, i.e. they do not admit explicitly infinite quantities. Here we discuss two non-archemedean approaches in the analysis of SCM, p-adic analysis and non-standard analysis. The first method is presented in Cosmology for two decades, in particular in establishing non-archemedan string theory (p-adic strings, adelic cosmology), by many authors: P. G. Freund, E. Witten, A. Yu. Krhennikov, I.V. Volovich, B. Dragovich. The non-standard analysis was less presented, except in explaining certain phenomena in quantum physics (S. Albeverio, J.E. Fenstad, T. Lindstrom). We remark that infinite quantities reflect certain non-archemedean properties of underlying structure. Our aim is to consider p-adic numbers versus non-standard reals, in particular in regard to the infinitesimal notions, constructions and related transfer techniques. Some applications in the study of CSM will be given.

International Conference on

CLASSICAL DYNAMICS IN ATOMIC AND MOLECULAR PHYSICS

BOOK OF ABSTRACTS

August 30 - September 2, 1988
Brioni, Yugoslavia

CLASSICAL TRAJECTORY METHOD IN LINE SHAPES INVESTIGATIONS

Milan S. Dimitrijević
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In spite of the existence of more refined quantum-mechanical approaches, the semiclassical method is still most widely used technique for the calculation of spectral line shapes. Morever, the classical method is frequently used in some special cases, e.g. in the adiabatic limit, where the semiclassical methods break down. In the semiclassical as well as in the classical method the perturber particle trajectory is commonly represented by a straight line in the case of neutral and a hyperbola in the case of ionized emitters. In some cases, e.g. at low temperatures, the effect of back reaction of the emitter on a perturbing particle may become noticeable and consequently, deviations of the perturber motion from the uniform one should be taken into account[1-4].

Here, the use of classical perturber trajectories within semiclassical and classical approaches to the line shapes and frequency shift calculations is briefly reviewed and discussed with special emphasis on the deviation of the perturber motion from the uniform one.

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COULOMB CUT-OFF POTENTIAL AND MODELING OF RADIATION AND COLLISION PROCESSES IN DENSE PLASMAS

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The methods of classical mechanics are very often sucesfully used for the description of processes in plasma |1|. Here, these methods are used to interpret processes in dense, strongly or totally ionized plasma. We study the processes of elastic scattering of electrons screened ions which influence considerably the transport properties of plasma, first of all, its electroconductivity. Further, we consider radiation processes appearing in electron-ion collisions and the influence of these collisions upon phase shifts and line broadening.

As a basis for these considerations a model of Coulomb cut-off potential is used and special attention is paid to its characteristics. This is in close connection with a number of properties of electron scattering on the mentioned potential in low energy region. Since the Coulomb cut-off potential is used here as effective potential in which the electron is scattered on the screened ion (the collective process which turns into one-particle process in this model), an investigation of this scattering is necesary for the interpretation of the obtained results. This pertains specially to such properties of the Coulomb cut-off potential as backward scattering ("giant gloria") at a given energy and to the resonant structure of the total cross section for elastic scattering at low energies |2,3 |.

It is show that within the range of relatively high energies (important in describing plasma processes) scattering may be described with satisfactory accuracy using the methods of classical mechanics. This pertains specially to the determination of transport cross section, the knowledge of which being important for the description of transport properties of plasma, here-electroconductivity. The model of Coulomb cut-off potential is used also for the description of "bremstrahlung" and for the description of influence of electron-ion elastic scattering on the phase shift and line broadening.

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188/III

THRESHOLD LAWS FOR THE FOURFOLD IONIZATION BY ELECTRONS

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We derive the near-threshold behaviour of the fivefold escape function for the process

$$e + A^{(q\pm)} \rightarrow A^{|(q\pm)+(4+)|} + 5\,e$$

where A can be an atom or molecule and q is an integer or zero, by employing the classical method due to Wannier |1|, in the form given by Vinkalns and Gailitis |2,3|. The purpose of these calculations is twofold : firstly, to extend the present multiple-ionization results to the process which now could be measured and secondly, to provide the next member of the so-called fractional-exponents sequence |4|, $\varkappa_n/n$, where $\varkappa_n$ is the threshold exponent and n is the multiplicity of ionization. The method used is a direct extension of that employed in |4|, with some mathematical improvements. The leading configuration appears to be double tetrahedron (D_3 symmetry), with the remaining ion resting at the centre.

As usually, case with the zero total angular momentum has been treated, but the results are valid for the general case of an arbitrary angular momentum |3|.

The present method can be extended for the ionization processes with higher multiplicities, but becomes rather cumbersome.

The work is supported financially by RZN of Serbia.

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International Conference on

CLASSICAL DYNAMICS IN ATOMIC AND MOLECULAR PHYSICS

BOOK OF ABSTRACTS

August 30 - September 2, 1988
Brioni, Yugoslavia

NEAR-THRESHOLD CID PROCESSES: NUMERICAL STUDIES

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Recently, we have put forward a classical method, based on the Wannier-type near-threshold fragmentation theory, in treating processes of the type

$$A + B_2 \rightarrow B + A + B$$

at small final fragments energies |1|. The method goes beyond the usual classical picture of the threshold breakup process (designed primarily for the Coulombic interaction) and predicts a number of specific features of some measurable quantities, for the case of the interatomic long-range forces.

This analytical approach is tested numerically, by simulating the fragmentation, making use of the classical trajectory method. The classical computer code for the three-body Coulombic systems |2| has been adapted for this purpose, as a further generalization of the previous elaboration on accounting for the internal structures of the interacting ions and atoms |3|.

Threshold laws for a number of molecular systems has thus been tested, and some distribution functions for the plane case configurations are being evaluated. Numerical results will be presented at the conference.

The work has been partially supported by RZN of Serbia and is a part of the common project through the British Council, ALIS LINK No 198 .

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MEMORY: FROM INDIVIDUAL TO SOCIETY, FROM QUANTUM TO COSMOS

The paper will approach the memory, seen as a complex phenomenon. We will analyze it as a process of the human brain, but we will also speak about materials with memory, showing that memory is not the privilege of the living world. We will pass from the quantum memory to the memory of stars, trace of the history of the universe. Memory is linked by the human spirituality and by the artistic creation. "Collective memory" will be also analyzed as a means to ensure the cultural and religious unity of a community, with focus on the ethnographic traditions and religious practices. What is the origin of the memory? Can we identify quantum discontinuities in human memory? Can we think of extending humankind's memories? These are some concrete questions to be answered.

MILAN DIMITRIJEVIC, SERBIA

ASTRONOMY AND THE GREAT QUESTIONS ABOUT UNIVERSE

Astronomy is a Science which marked our epoch. The man made his first step on the Moon, our spacecrafts visited all known planets of the Solar system and great cosmic observatories made a dramatic revolution in our knowledge on the Universe. Astronomy considers the big questions about Universe and try to find answers on the fundamental scientific, philosophical and spiritual questions about our origin and final destiny. In this contribution some of such questions will be discussed. Are we alone or there is a multitude of cosmic civilizations? What is the contemporary scientific view on the origin of the Universe and on its final destiny? Are we living in a Universe perfectly tuned to enable our existence (antrophical principle) or the universal constants and natural laws are originated by chance or they are changable? Are we in a deterministic world where our destiny is predictable or in an indetereministic one? We will discuss some possible answers, opinions and considerations.

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DEPARTMENT OF PHYSICS AND ASTRONOMY

Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysics and Fusion Research

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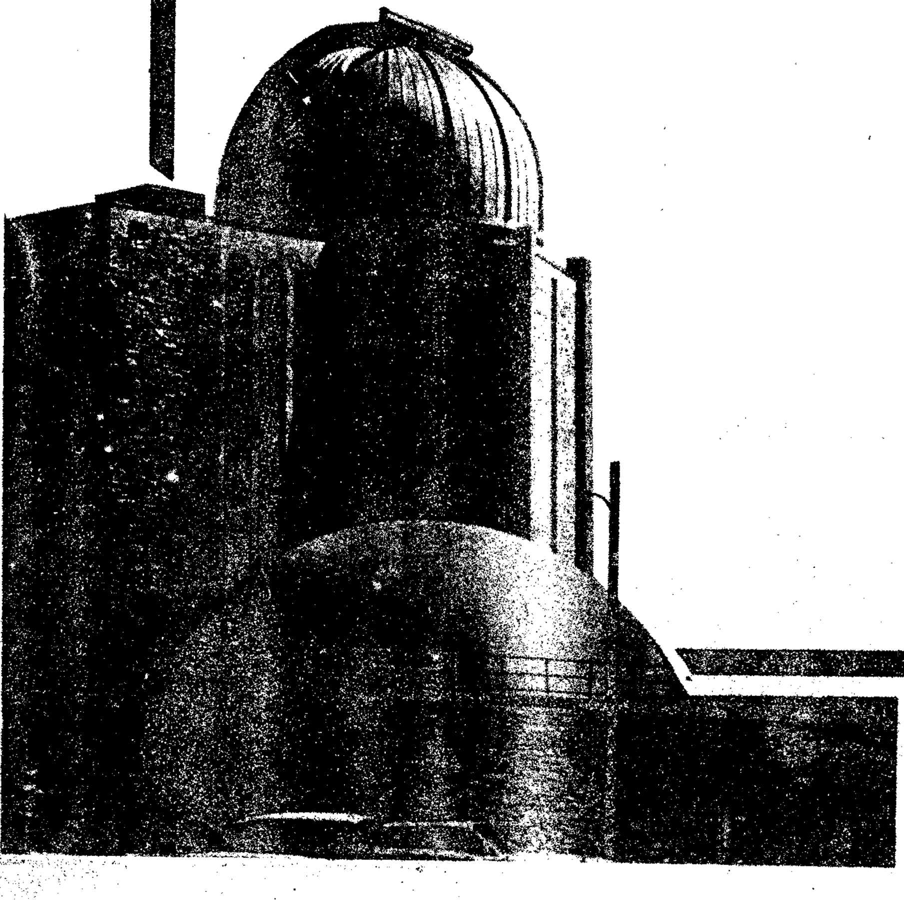

P7

Se. Johansson and G. Norlén

University of Lund

Interferometric measurements of Fe II transition wavelengths in the IUE region

Accurate wavelengths (< 0.001 Å) are presented for more than 200 Fe II lines in the region 1000 - 2000 Å. In the range 2000 - 3000 Å interferometric measurements have been made for more than 300 Fe II lines.

P8

V.Kršljanin and M.S.Dimitrijević
Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavia

MODIFIED SEMIEMPIRICAL APPROACH AS A SOURCE FOR STARK BROADENIG DATA IN ASTROPHYSICS: Li-LIKE RESONANCE LINES IN STELLAR ATMOSPHERES

The modified semiempirical theory[1,2] of electron-impact broadening[1] and shift[2] of ion lines was found to be a simple, fast and satisfactory accurate data source for astrophysical spectroscopy. Very simple analytical fits for widths and shifts (as a function of Z and χ_{exc}) of Li isoelectronic sequence resonance lines are obtained. Connections with the observed shifts and shapes of CIV, NV, OVI resonance lines in stellar spectra are discussed. Stark shifts of these lines in the hot stellar atmospheres, as a function of line formation optical depth, are calculated, and importance of the Stark shifts in spectra of high gravity stars is confirmed.

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P9

J Lang, R A Hardcastle, R W P McWhirter and P H Spurrett

Space and Astrophysics Division, Rutherford Appleton Laboratory, Chilton,
Didcot, Oxon, OX11 0QX, UK

New Measurements of Spontaneous Transition Probabilities for Beryllium-like Ions

Measurements of spectral line intensities for pairs of transitions with common upper levels are reported. When combined with results of measurements of radiative lifetimes of the upper levels by other authors, values of the individual transition probabilities are obtained. The results are for transitions in N IV, O V and Ne VII and are claimed to be accurate to between 7% and 38%. Comparison with theoretical values shows good agreement for some of the simpler electric dipole transitions, while for other transitions discrepancies of up to x 5 are found.

COLLISION DYNAMICS OF CLUSTERS AND LONG-LIVED STATES

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TRIATOM FRAGMENTATION NEAR THE BREAKUP THRESHOLD

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In many molecular processes various long-lived transient states may be formed, which subsequently decay into i number of exit channels. We are interested in the fragmentation probability for triatomic complexes, just above the breakup threshold.[1] The classical theory, based on Wannier's model, has been developed for the inverse-power interaction potentials.[2] For the s - waves final configurations the threshold law for the van der Waals case reads

$$\sigma_b \sim (E_{tot} - E_{th})^{1.526}$$

where E_{tot} and E_{th} are the total energy and endoergicity of the system, respectively.

Computer simulations of the process : $A + A_2 \rightarrow (AAA)^* \rightarrow A + A + A$ should check this energy dependence for the linear configurations and also estimate the contribution from the nonzero-angular-momenta final states. Numerical calculations for the 3He complex, with the Lennard - Jones potential,[3] are in progress and we hope to present the results at the Conference.

This work has been supported in part by RZN of Serbia.

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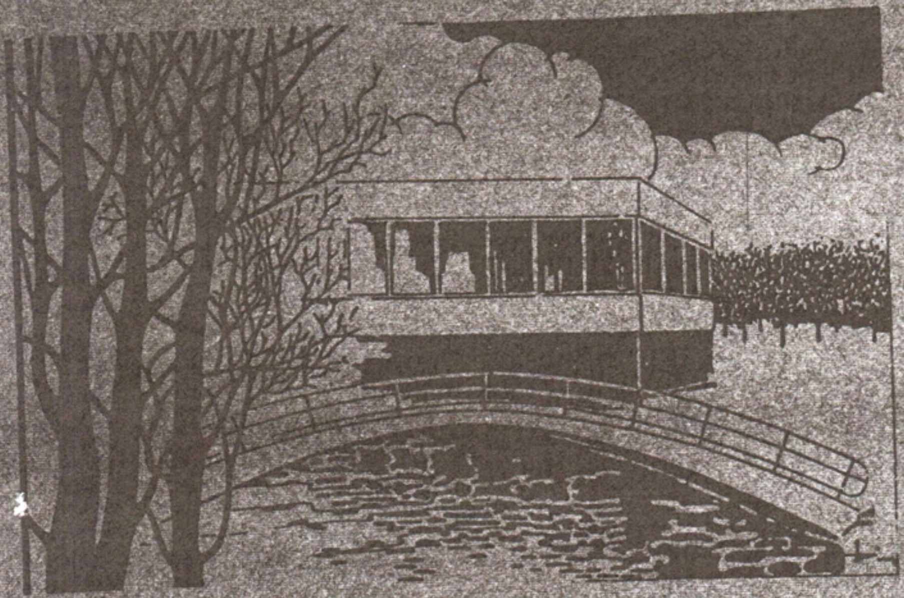

ORLEANS
18-20 SEPT.1985

A SIMPLE FORMULA FOR ESTIMATING STARK BROADENING PARAMETERS OF NEUTRAL ATOM LINES

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For evaluation of Stark line widths and shifts of non-hydrogenic spectral lines of neutral atoms, various theoretical approaches have been used (see e.g. Ref. 1). Most of these approaches require a considerable labour even for the evaluation of a single line width. Whenever a large number of theoretical data are required, tedious calculations can be avoided if one uses simple, approximative formulae with good average accuracy.

In 1978, Freudenstein and Cooper[2] suggested a simple method for evaluation of electron-impact widths of neutral atom lines, based on the simplification of GBKO[3] method. We develop here this approach further and extend its applicability to the shift calculations also.

The half-half width (w) and shift (d) of a neutral atom spectral line broadened by electron impacts are given by[3]

$$w+id=\frac{4\pi}{3}N_e\left(\frac{\hbar}{m}\right)^2\int\frac{dv}{v}f(v)\Big\{\frac{1}{2}\tilde{\varrho}^2_{min}+\sum_{i'}\vec{R}^2_{ii'}\left[a_{ii'}(z^{min}_{ii'})-\right.$$
$$\left.-i\,\varepsilon_{ii'}b_{ii'}(\tilde{z}^{min}_{ii'})\right]+\sum_{f'}\vec{R}^2_{ff'}\left[a_{ff'}(z^{min}_{ff'})+\right.$$
$$\left.+i\,\varepsilon_{ff'}b_{ff'}(\tilde{z}^{min}_{ff'})\right]\Big\} \qquad (1)$$

where $\vec{R}^2_{jj'}$ (in units of the Bohr radius a_o^2) is the square of the coordinate operator matrix element. N_e is the electron density, f(v) is the Maxwellian distribution of the electron velocity, i,f denote the initial and final states, and i′,f′ are the corresponding perturbing states within the dipole approximation. The quantity $\varepsilon_{jj'}$ determines the signs of indivi dual contributions to the shift, viz.

$$\varepsilon_{jj'} = (E_j - E_{j'})/|E_j - E_{j'}|,$$

where E_j and $E_{j'}$ are the energies of the corresponding states. The minimum impact parameter ρ_{min} allowed by the unitarity cond tion[3] is given by

$$\tilde{\rho}^2_{min} = \Big| \sum_{i'} \vec{R}^2_{ii'} [A_{ii'}(z_{ii'}) - i\varepsilon_{ii'} B_{ii'}(\tilde{z}_{ii'})] + \tag{2}$$

$$+ \sum_{f'} \vec{R}^2_{ff'} [A_{ff'}(z_{ff'}) + i\varepsilon_{ff'} B_{ff'}(\tilde{z}_{ff'})]\Big|,$$

where $a_{jj'}$, $b_{jj'}$, $A_{jj'}$ and $B_{jj'}$ are the GBKO[3] Stark broadening functions of the arguments $z_{jj'}$ and $\tilde{z}_{jj'}$,

$$z_{jj'} = \rho(E_j - E_{j'})/\hbar v, \quad \tilde{z}_{jj'} = 0{,}75\, z_{jj'},$$

and ρ is the impact parameter.

In order to simplify Eqs. (1) and (2), we introduce here the approximation

$$\Big| \sum_{j'} \vec{R}^2_{jj'} [A_{jj'} + i\varepsilon_{jj'} B_{jj'}] \Big| \approx \sum_{j'} \vec{R}^2_{jj'} \big| [A_{jj'} + i\varepsilon_{jj'} B_{jj'}] \tag{3}$$

For a series of complex numbers z_j we have $|\sum_j z_j| \leqslant \sum_j |z_j|$, where the signe of equality holds in the case when all z_j have equal arguments. This means that $A_{jj'} \gg B_{jj'}$ which is satisfied for close collisions, high velocities or close perturbing levels, giving usually the principal contribution to the line broadeni

Define $\eta_{jj'} \equiv |E_j - E_{j'}|/3KT$. Then

$$W + id \approx 1.089 N_e \pi \left(\frac{\hbar a_0}{m}\right)\left(\frac{E_H}{kT}\right)^{1/2} \Big\{ \sum_{i'} \vec{R}^2_{ii'} \Big[f_w(\eta_{ii'}, \vec{R}_{ii'}) - i\varepsilon_{ii'} f_d(\eta_{ii'}, \vec{R}_{ii'})\Big] + \sum_{f'} \vec{R}^2_{ff'} \Big[f_w(\eta_{ff'}, \vec{R}_{ff'}) + + i\varepsilon_{ff'} f_d(\eta_{ff'}, \vec{R}_{ff'})\Big]\Big\}, \tag{4}$$

where

$$f_w(\eta_{jj'}, \vec{R}_{jj'}) = \frac{1}{2}\left[A^2(z^{min}_{jj'}) + B^2(z^{min}_{jj'})\right]^{1/2} + a(z^{min}_{jj'}) \tag{5}$$

as suggested by Freudenstein and Cooper[2], and

$$f_d(\eta_{jj'}, \vec{R}_{jj'}) = \left(\frac{6}{\pi}\right)^{1/2} b(\tilde{z}^{min}_{jj'}). \tag{6}$$

The multiplicative factor of $(6/\pi)^{1/2}$ in the expression for f_d occures owing to the difference in the velocity average. To obtain f_w and f_d it is necessary only to solve the following equation

$$(z^{min}_{jj'})^2 = \frac{2}{3}(\eta_{jj'} \vec{R}_{jj'})^2 \left[A^2(z^{min}_{jj'}) + B^2(z^{min}_{jj'})\right] \tag{7}$$

obtained from Eq.(2) and then substitute the solution into Eqs. (5) and (6). The functions $f_w(x)$ and $f_d(x)$ (where $x = \eta_{jj'} \cdot \vec{R}_{jj'}$) may be fitted numericaly[4] with an expression of the form

$$f_j(x) = e^{-a_j x} \ln\left(1 + \frac{b_j}{x}\right) + \frac{c_j x}{d_j + x^{5/3}} + \frac{x}{e_j + x^3}, \; j = w, d \tag{8}$$

where a, b, c, d, and e are constants.

In Table 1, our results obtained using Eqs. (4) and (8) are compared with results from Ref. 5 and according to Ref. 2. We can see that in the simple case of $2p\,^1P - 5s\,^1S$ transition, all calculations are in agreement. In the case of He I $2p\,^1P - 3d\,^1D$ line, where we have not a dominant perturbing level, our calculations for the width agree better with BG results. In this case, the agreement of results for shift is worse than in previous

We belive that the simple formulae presented here, will be useful when astrophysicists or physicists require a large number of neutral atom line widths and shifts influenced by th Stark effect.

Table 1. Half-half widths and shifts in Å: DK-present results, BG-results from Ref. 5 (also given in Ref.1); FC-res calculated according to Ref. 2. $N_e=10^{16}cm^{-3}$

T(K)	W_{DK}	W_{BG}	W_{FC}	d_{DK}	d_{BG}
He I $2p^1P-5s^1S$ 4438 Å line					
5000	1.47	1.41	1.34	2.39	1.51
10000	1.78	1.57	1.64	2.05	1.43
20000	1.87	1.65	1.72	1.56	1.24
30000	1.80	-	-	1.29	-
40000	1.73	1.62	1.60	1.12	0.996
He I $2p^1P-3d^1D$ 6678 Å line					
5000	0.676	0.423	0.948	0.514	0.275
10000	0.609	0.386	0.825	0.392	0.233
20000	0.542	0.349	0.696	0.295	0.196
30000	0.501	-	-	0.244	-
40000	0.471	0.318	0.573	0.212	0.161

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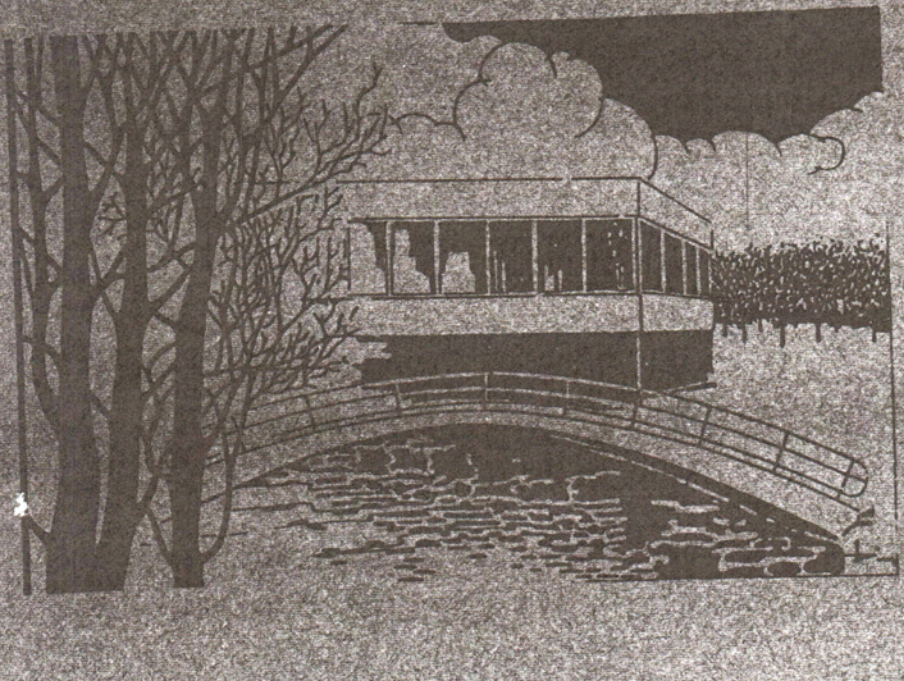

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L'ELARGISSEMENT STARK DES RAIES DU POTASSIUM NEUTRE

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A l'aide du formalisme semiclassique-perturbations pour l'élargissement Stark des raies spectrales, nous avons calculé les largeurs et les déplacements de 50 raies spectrales du potassium neutre[1], dus aux collisions avec les électrons, les protons et l'argon ionisé, dans l'approximation des impacts. Nous avons utilisé une version de la théorie semi-classique[2,3] differant en plusieurs points de l'autre version qui a été appliquée à l'élargissement et au déplacement des raies du potassium. Notre échantillon de raies est aussi beaucoup plus important.

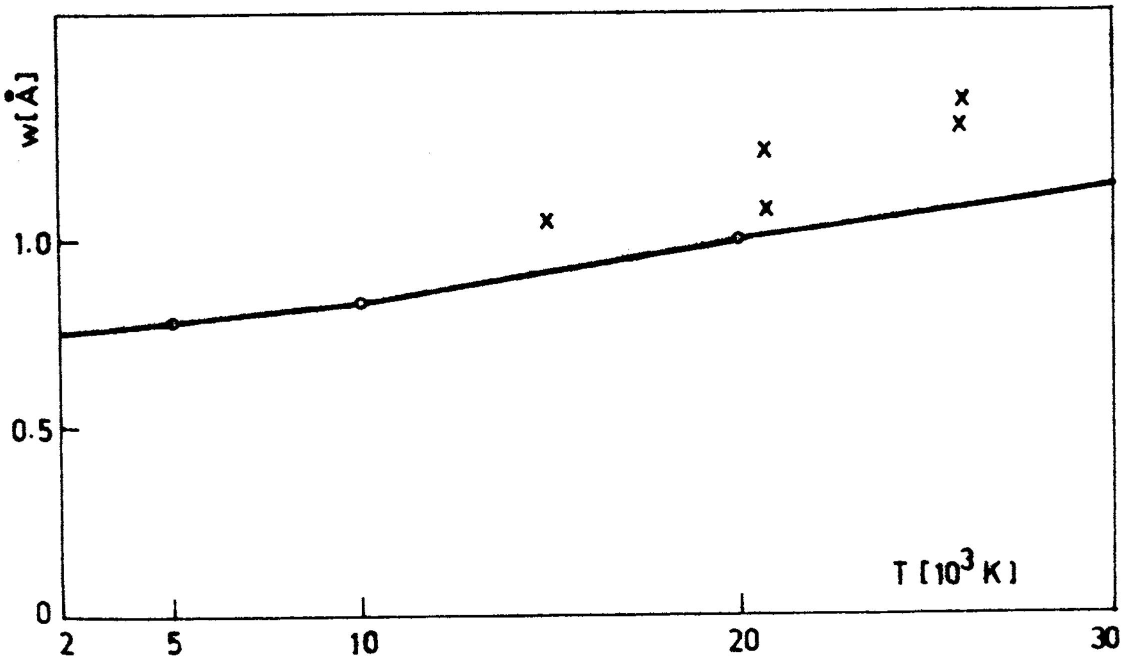

Figure 1. Largeur totale de la raie K I $4s\,^2S-4p\,^2P$ en fonction de la température électronique; $N_e = 10^{17}cm^{-3}$. Les X représentent les résultats expérimentaux de Purić et al.[6]

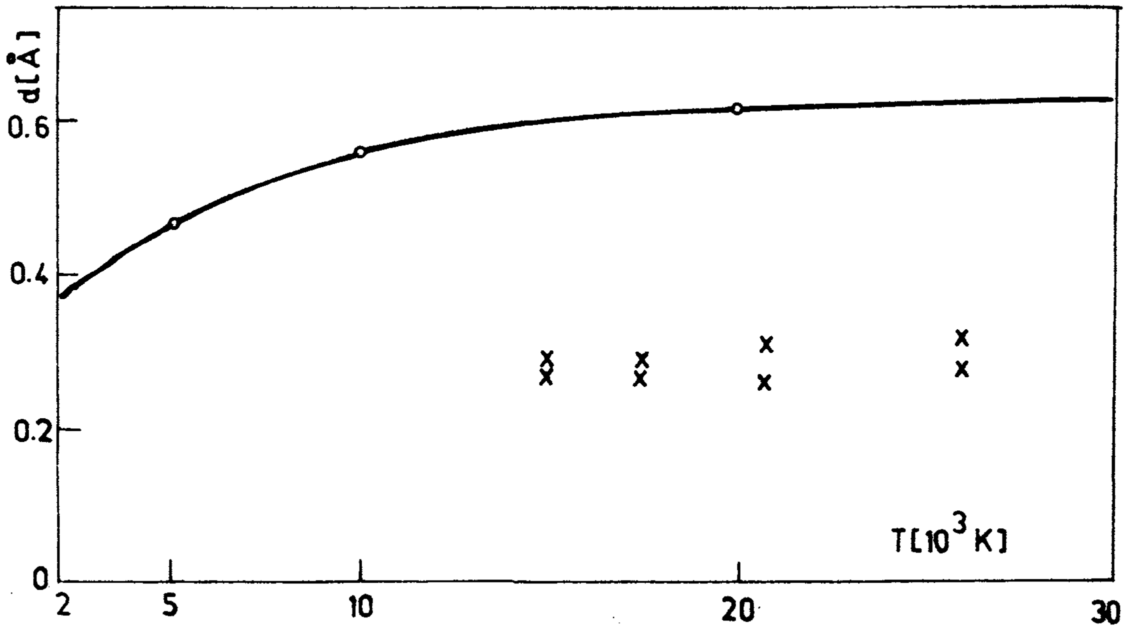

Figure 2. Idem Fig. 1 mais pour les déplacements

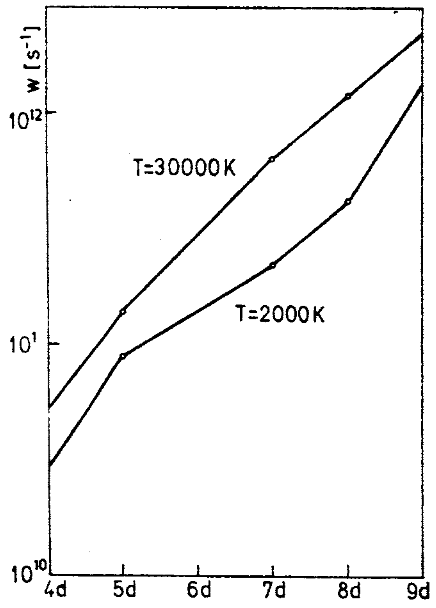

Figure 3. Variation avec le nombre quantique principal, n de la demi-largeur w de la ra du potassium $5p^2P$-nd^2D, du aux collisions électroniqu pour T=2000 et 30oooK. N_e=$1o^{15}cm^{-3}$.

Nous avons ensuite utilisé nos résultats pour étudier les comportements et les régularités des largeurs et des déplacements avec la température et surtout avec le nombre quantique principal: on peut alors obtenir de nouvelles données par interpolation et discuter les résultats expérimentaux.

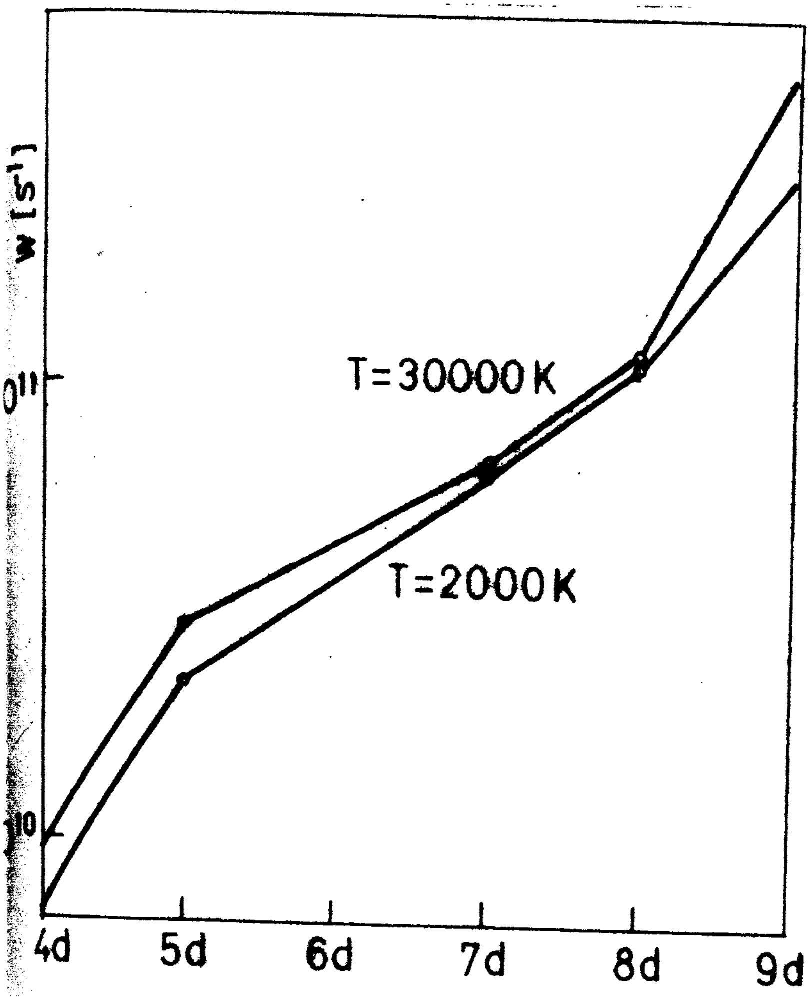

Figure 4.
Variation avec le nombre quantique principal n de la demi-largeur w de la raie du potassium $5p^2P-nd^2D$ due aux collissions **avec** les protons. $N_e=10^{15}cm^{-3}$.

Les figures 1-4 illustrent les résultats obtenus. Les figures 1 (largeur) et 2 (déplacement) concernent la comparaison entre nos calculs (l'élargissement due aux collisions avec les électrons et l'argon ionisé) et les résultats expérimentaux[6]. On peut voir un bon accord entre les calculs et les résultats expérimentaux dans le cas du déplacement.

Les figures 3-4 illustrent la régularité du comportement en fonction du nombre quantique principal n, d'une serie de largeurs dùs aux chocs avec les électrons (Figure 3) et les protons (Figure 4). On peut voir que la largeur augmente avec le nombre quantique principal de façon régulière comme on s'y attend (voir e.g. Refs. 7 et 8).

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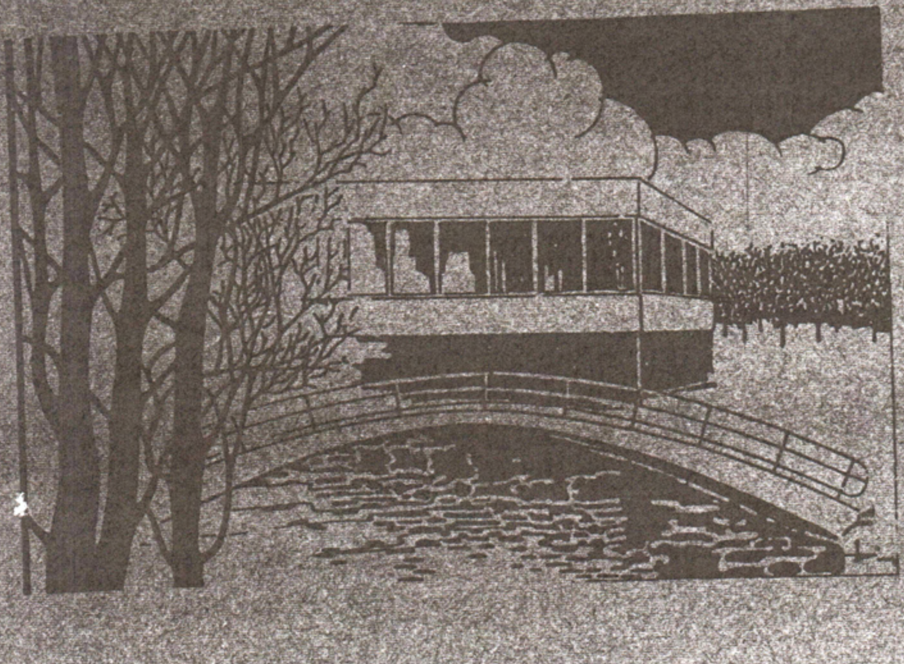

ORLEANS
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SUR L'INEGALITE DES LARGEURS STARK A L'INTERIEUR D'UN MULTIPLET OU SUPERMULTIPLET DE L'ARGON II

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ABSTRACT- Les paramètres Stark de divers composants à l'intérieur du multiplet $4s^2P-4p'^2P°$ et du supermultiplet 4p-4d ($^2P°-^2P$, $^2D°-^2P$, $^2D°-^2D$) de l'ArII sont calculés suivant un formalisme semi-classique. La possibilité de différence entre ces largeurs ou déplacements est discutée en fonction de l'effet d'écran Debye et des irrégularités dans le diagramme des niveaux d'énergie .

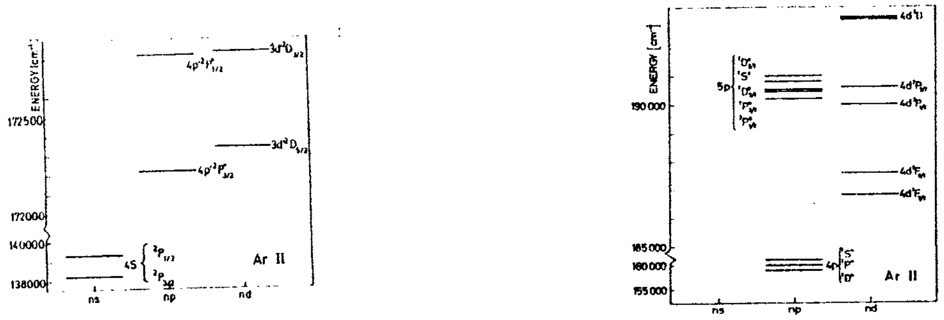
1. INTRODUCTION

Les largeurs Stark des composants d'un même multiplet sont presque égales /1/ quand la structure des niveaux d'énergie atomique est régulière /2/.Pour une structure irrégulière,ces largeurs peuvent être très différentes /2/ dans bien de cas /2/.Une différence jusqu'à 39% a été observée par Behringer et Thoma /3/ pour le multiplet $4s^2P-4p'^2P°$ de l'ArII.Celle-ci a été expliquée par les calculs semi-empiriques de Hey /4/ en se basant sur la présence du niveau perturbateur $3d'^2D_{\frac{3}{2}}$ très proche de $4p'^2P^\circ_{\frac{1}{2}}$ (Fig.1) .Récemment Konjevic et Kobilarov ont remarqué /5/ que cette explication satisfaisante ne tient pas compte de l'effet d'écran.Celui-ci,négligeable dans la plupart des calculs d'élargissement Stark,devient important quand il s'agit d'un niveau perturbateur proche.Par des formules simplifiées /6/ qui tiennent compte de cet effet,ils ont montré que ces largeurs devraient être les mêmes.

Afin de clarifier cette controverse et aussi dans l'intérêt d'astrophysique,nous étudions les largeurs et déplacements Stark des composants du multiplet $4s^2P-4p'^2P°$ et du supermultiplet 4p-4d ($^2P°-^2P$, $^2D°-^2P$, $^2D°-^2D$) de l'ArII.Nos calculs utilisent un formalisme semi-classique /4/ qui tient compte de l'effet Debye (via des coupures du paramètres d'impact électronique à la longueur Debye) et de la contribution des résonances Feshbach /7/.

FIG. 1. Diagramme des niveaux pour le multiplet $4s^2P-4p'^2P^\circ$

pour le supermultiplet 4p-4d



2. RESULTATS ET DISCUSSIONS

Les niveaux d'énergie atomique d'ArII sont donnés par Ref./8/.Les forces d'oscillateur sont calculées dans le modèle Thomas-Fermi /9/ . Nos résultats et ceux de Konjevic et Kobilarov pour le multiplet $4s^2P-4p'^2P^\circ$ convergent vers la même conclusion (Table 1): l'effet d'écran fait décroitre la différence entre les largeurs calculées et rend inexplicable l'écart de 39% mesuré par Behringer et Thoma .Des considérations particulières suggèrent /10/ l'intérêt de nouvelles mesures indépendantes en vue d'une comparaison théorie-expérience. Pour le supermultiplet,la Figure 2 montre les mêmes largeurs à l'intérieur du multiplet $^2D^\circ-^2D$, mais des différences notables pour les multiplets $^2P^\circ-^2P$, $^2D^\circ-^2P$ qui pourraient être expliquées par la présence des niveaux perturbateurs 5p proche de $4d^2P$ (Fig.1).

TABLE 1. Largeurs Stark (FWHM) du multiplet $4s^2P-4p'^2P^\circ$ mesurées (W_m) et calculées : W_{se},Hey semi-empirique,sans Debye; W_{KK},Konjevic et Kobilarov,avec Debye; W_{sc},présents calculs,avec Debye.

λ(Å)	J_f	J_i	W_m(Å)	W_{se}(Å)	W_{KK}(Å)	W_{sc}(Å)
2892	3/2	1/2	0.326	0.236	0.336	0.243
2943	3/2	3/2	0.202	0.194	0.330	0.240
2979	1/2	1/2	0.302	0.252	0.357	0.258
3034	1/2	3/2	0.333	0.206	0.351	0.255

1) $^2P^\circ-{}^2P$ 3/2 - 3/2
2) 1/2 - 3/2
3) 3/2 - 1/2
4) 1/2 - 1/2
5) $^2D^\circ-{}^2D$ 3/2 - 3/2
6) 5/2 - 5/2
7) 3/2 - 5/2
8) $^2D^\circ-{}^2P$ 3/2 - 1/2
9) 5/2 - 3/2

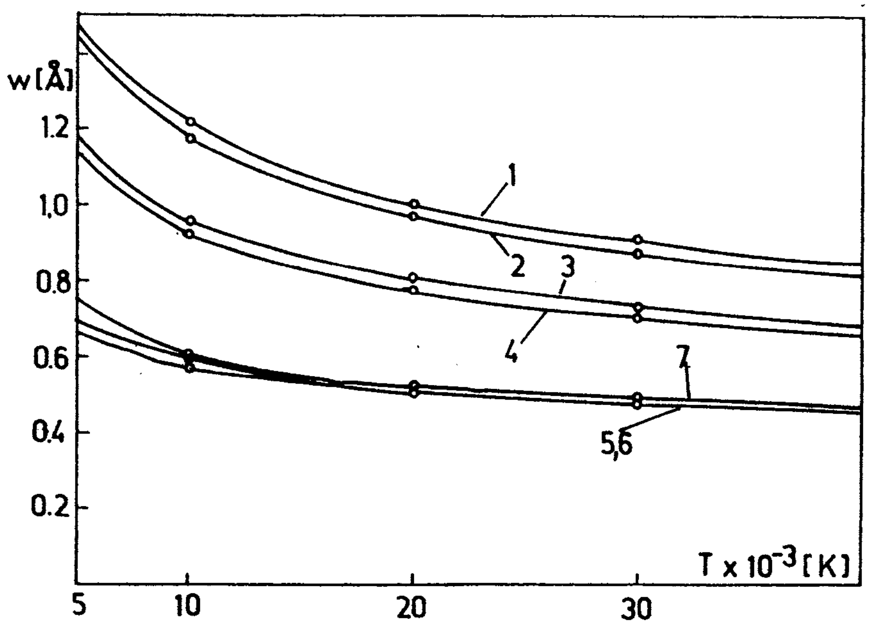
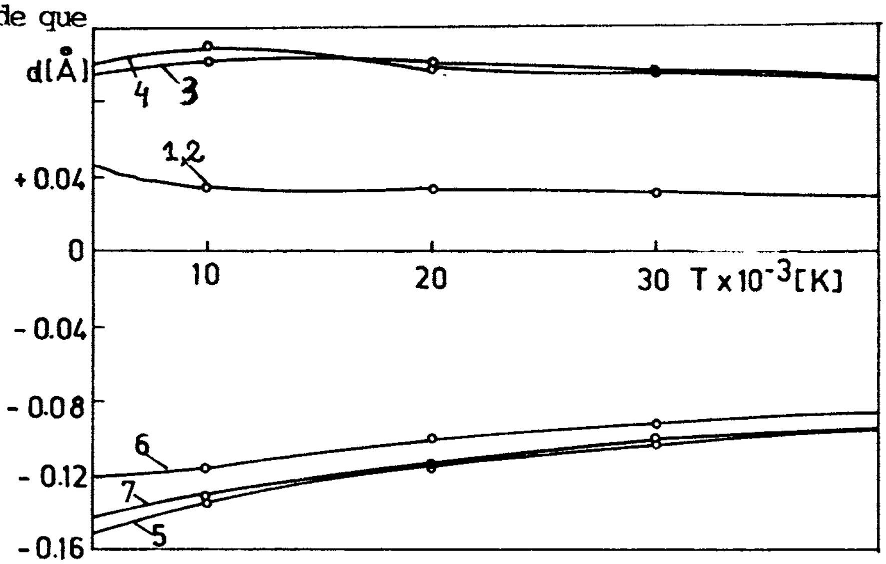


FIG. 2. Largeurs du supermultiplet 4p-4d

Les déplacements à l'intérieur de $4s\,^2P-4p'\,^2P^\circ$ se diffèrent d'un facteur 2. Pour le supermultiplet,ils changent de signe quand on passe des multiplets $^2P^\circ-{}^2P$, $^2D^\circ-{}^2P$ à $^2D^\circ-{}^2D$.Ceci est dû à un changement de sens de perturbation (Fig.3) : les niveaux perturbateurs principaux $5p\,^2P^\circ$ sont plus bas que $4d\,^2D$ pour le dernier multiplet alors que le niveau perturbateur principal $5p\,^2S^\circ$ est plus haut que $4d\,^2P$ pour les 2 premiers multiplets.

FIG. 3. Même légende que dans Fig.2 pour les déplacements.



En conclusion, à l'intérieur d'un supermultiplet ou transition array les paramètres Stark peuvent être différents. Les déplacements sont en général plus sensibles aux irrégularités des niveaux d'énergie atomique que les largeurs et dans certains cas ils pourrions avoir des signes opposés (voir aussi Ref.11). Cependant pour ne pas surestimer l'importance des niveaux perturbateurs proches qui constituent l'origine des écarts entre les largeurs calculées ,il est prudent de tenir compte de l'effet d'écran Debye.

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COLLISIONS
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ON THE STARK BROADENING PARAMETERS FOR Li-LIKE IONS

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Resumé: A l'aide du formalisme semiclassique-perturbations pour l'élargissement Stark des raies spectrales, nous avons calculé les largeurs et les déplacements des raies dans la sequence isoelectronique du lithium. Les resultats obtenus ont été comparé avec les calcules quantiques.

Summary: Using semiclassical perturbational approach, Stark broadening parameters along lithium isoelectronic sequence have been calculated. Obtained results have been compared with quantum mechanical calculations.

Several papers have been published recently dealing with the investigation of Stark broadening parameters along isoelectronic sequences (e.g. 1,2), especially in order to enable interpolation of measured and calculated Stark widths. Within the frame of the semiclassical-perturbational theory (3,4) we performed calculation of Stark widths and shifts for spectral lines along lithium isoelectronic sequence. Calculations were performed using line strengths from Ref. 1.

As an example of obtained results, Stark broadening parameters for C IV, N V and O VI 2s-2p lines are given in Table 1 as a function of temperature. Thermally averaged collision strengths for C IV 2s-2p line are compared in Table 2 with quantum mechanical (strong coupling) calculations (1). One can see that (especially in the case of the shift) results agree slightly better for higher temperatures.

Table 1: Stark broadening parameters: full halfwidths (2W) and shifts (d) for C IV, N V and O VI 2s-2p lines. The electron density is 10^{17} cm^{-3} .

Transition	T(K)	2W(Å)	d(Å)
C IV $2s\,^2S-2p\,^2P^o$	45000	0.725-2	-0.270-3
	90000	0.505-2	-0.259-3
	180000	0.364-2	-0.299-3
	360000	0.273-2	-0.300-3
N V $2s\,^2S-2p\,^2P^o$	80000	0.297-2	-0.783-4
	160000	0.210-2	-0.754-4
	320000	0.152-2	-0.915-4
	640000	0.114-2	-0.879-4
O VI $2s\,^2S-2p\,^2P^o$	125000	0.134-2	-0.340-4
	250000	0.959-3	-0.326-4
	500000	0.697-3	-0.392-4
	1000000	0.524-3	-0.357-4

Table 2: Thermally-averaged collision strengths for C IV line profiles. ($t=10^{-4}T/Z^2$; Z-ionization stage)

Transition	t	Our results		Seaton (1988)	
C IV $2s\,^2S-2p\,^2P^o$	0.5	14.2	-1.04i	8.1	-2.9i
	1.0	13.8	-1.41i	8.1	-3.1i
	2.0	14.1	-2.31i	8.4	-3.1i
	4.0	14.9	-3.28i	9.3	-3.2i

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COLLISIONS

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A study of the atmospheric structure of AX Mon (HD 45910)

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Abstract

In this paper we apply the GR model to find kinematic parameters (radial, rotational and random velocities) as well as FWHM, the absorbed energy and the Gaussian Typical Deviation (σ) for a group of Fe II spectral lines from AX Mon spectra obtained with IUE. In order to find possible stratification in the Fe II absorbing region of AX Mon we present these parameters as a function of the excitation potential of the lines. We found that the obtained parameters are not too sensitive to the excitation potential of the Fe II lines. In addition, we calculate the above mentioned parameters for the Al II (λ 1670.81 Å), Al III ($\lambda\lambda$ 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines of AX Mon, and we present their relation with the ionization potential.

Individual Objects: AX Mon, HD 45910

Results and discussion

Using the Gauss Rotation (GR) model (Danezis et al. 1991, 2007) we accomplished the best fit of the Al II (λ 1670.81 Å), Al II ($\lambda\lambda$ 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines of HD 45910 (AX Mon). The complex structure of these spectral lines can be explained with Discrete Absorption components (DACs) and Satellite Absorption components (SACs, Danezis et al. 2007).

Variation of parameters as a function of the excitation potential

The radial and rotational velocities of the studied group of Fe II lines show small changes as a function of the excitation potential. The radial velocities present three levels. The first level has values of about -260 km/s, the second one has values of about -125 km/s and the third one has values of about -18 km/s. These values are in agreement with the respective values found by Danezis et al. (1991). The values of the rotational velocities for all SACs are between 20 and 60 km/s. In the case of the random velocities of the ions of the studied group of Fe II lines, we detected three levels of random velocities. The first level has values of about 115 km/s, the second one of about 70 km/s and the third one is about 35 km/s. The variation of the typical Gaussian deviation has the same form as the variation of the random velocities. There are also three levels of values. The first level has values of about 0.8, the

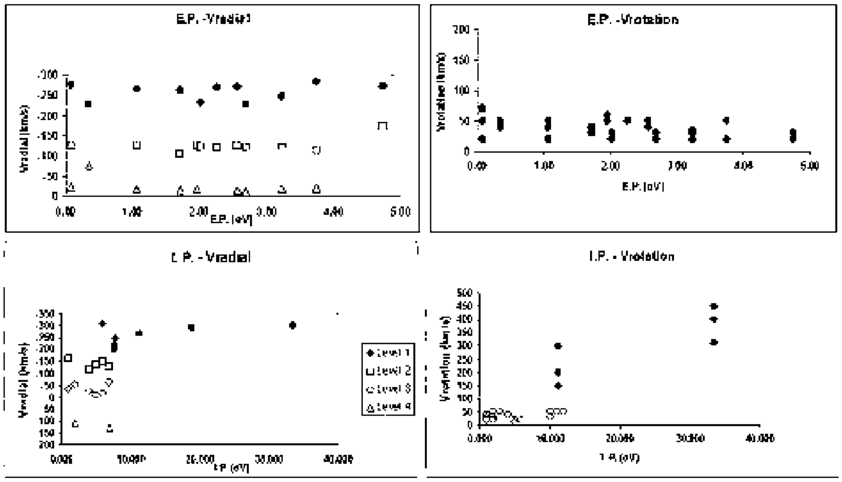

Figure 1: Radial and rotational velocities of the studied group of Fe II lines as a function of the excitation potential and radial and rotational velocities of the studied group of Al II (λ 1670.81 Å), Al III ($\lambda\lambda$ 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines as a function of the ionization potential.

second one of about 0.4 and the third one of about 0.2. The Full Width at Half Maximum (FWHM, Å) of the studied group of Fe II lines presents also three levels of values. The first level has values of about 2 Å, the second one of about 1.3 Å and the third one of about 0.6 Å. Finally, in the case of the absorbed energy (Ea, eV) of the studied group of Fe II lines we also found three levels of values. The first level is about 1 eV, the second one about 0.4 eV and the third one about 0.14 eV.

Variation of kinematic parameters as a function of the ionization potential

Here we present the variation of the radial and rotational velocities in the Al II ($\lambda\lambda$ 1670.81 Å), Al III ($\lambda\lambda$ 1854.722, 1867.782 Å), Mg II ($\lambda\lambda$ 2795.523, 2802.698 Å), Fe II (λ 2586.876 Å), C II ($\lambda\lambda$ 1334.515, 1335.684 Å) and Si IV ($\lambda\lambda$ 1393.73, 1402.73 Å) spectral lines as a function of the ionization potential. We detected four levels of radial velocities. The first level has values of about −260 km/s and corresponds to an ionization potential larger than 20 eV. The second level has values of about −140 km/s, the third one of about −35 km/s and the fourth one of about 119 km/s. All these values correspond to ionization potential with values between 0 and 10 eV. The values of the rotational velocities are 150 – 450 km/s and correspond to ionization potentials larger than 10 eV. The low values of the rotational velocities (10 – 50 km/s) correspond to ionization potentials with values between 0 and 10 eV.

Acknowledgments. This research project is progressing at the University of Athens, Department of Astrophysics, Astronomy and Mechanics, under the financial support of the Special Account for Research Grants, which we thank very much. This work also was supported by the Ministry of Science and Technological Development of Serbia, through the projects "Influence of collisional processes on astrophysical plasma line shapes" and "Astrophysical spectroscopy of extragalactic objects".

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ABSTRACTS

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Stark broadening parameters

M.S.Dimitrijevic, S.Sahal-Brechot

Stark broadening of spectral lines has been taking a new interest in astrophysics (Seaton, 1987), owing to the recent development of researches on the physics of stellar interiors: in subphotospheric layers, the modellisation of energy transport needs the knowledge of radiative opacities and thus, certain atomic processes must be known with accuracy.In order to provide a method for quick interpolation of new data along an isoelectronic sequence it is of interest to investigate if a sufficiently regular behaviour of Stark broadening parameters along such a sequence exists.

The present paper concerns Ca II, Sc III and Ti IV lines from the kalium isoelectronic sequence. Beyond the interest for the stellar atmospheres investigation and the modellisation of stellar interiors, the knowledge of Ca II, Sc III and Ti IV Stark broadening parameters is important for a number of problems in astrophysics and plasma physics. Particularly is important Ca II which is among the most abundant elements in stellar plasma after hydrogen and helium. In order to provide reliable data for the mentioned lines broadened by collisions with all important charged perturbers in stellar plasmas, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 28 Ca II (Dimitrijević et al, 1992ab), 10 Sc III and 10 Ti IV multiplets (Dimitrijević and Sahal-Bréchot, 1992c), using the semiclassical-perturbation formalism (Sahal-Bréchot, 1969ab). This is a part of an effort to provide reliable Stark broadening data for stellar plasma research (see the review on up to now performed calculations for He I, Na I, K I, F I, Be II, Mg II, Ca II, Sr II, Ba II, Si II, Ar II, Ga II, Ga III and several lines of other light elements, in Dimitrijević and Sahal-Bréchot, 1991).

The obtained results were used to investigate the behaviour of Stark broadening parameters within the isoelectronic sequencee in order to examine the use of such behaviour for the interpolation of new data of interest for the stellar plasma investigations. Our analysis shows that a regular behaviour exist but the mutual relation of the corresponding Stark broadening parameters depends on temperature. Additional experimental and theoretical work for the investigated case is needed as well as the extension to the other members of K isoelectronic sequence.

Stark broadening data for singly ionized beryllium lines are of interest in astrophysics since the surface content of Be provides informations on nucleogenesis, mixing between atmosphera and interior, the internal structure and evolution of a star (Boesgaard, 1988). Such data are of interest also for the analysis and diagnostics of stellar and laboratory plasmas. Moreover, the astrophysical importance of such data for the investigation of subphotospheric layers is discussed by Seaton (1987).

The present paper concerns singly ionized beryllium: In order to provide reliable data for Be II lines broadened by collisions with charged perturbers in stellar and laboratory plasmas, we have calculated electron−, proton−, and ionized helium−impact line widths and shifts for 30 Be II multiplets, using the semiclassical−perturbation formalism (Sahal−Bréchot, 1969ab). Thus, we have provided Stark broadening data for all of the important charged perturbers in stellar atmospheres. The obtained results for perturber density of 10^{15}cm^{-3}, together with discussion, analysis and comparison with existing experimental and theoretical data will be published in Dimitrijević, and Sahal−Bréchot, 1992a). Since data are not linear with perturber density (N), due to the Debye screening effect, which is often important at high densities of interest for subphotospheric layers, Be II Stark broadening data tables for N $= 10^{16} - 10^{19}$cm^{-3} together with the data for N $= 10^{13}$cm^{-3} of special interest for stellar atmospheres, will be published in Dimitrijević and Sahal−Bréchot, 1992b. All details of the calculation procedure has been described in Dimitrijević, Sahal−Bréchot, Bommier (1991).

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New Challenges of Astroinformatics - STARK-B Database and Serbian Virtual Observatory - SerVO, and Relations to European Virtual Atomic Data Center - VAMDC

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Abstract:
The development of space born astronomy, providing a huge amount of high quality astronomical data created an information avalanche and leaded to the formation of huge data collections. In order to address the problem how to analyse such amount of data, the idea of Virtual Observatory was formulated at the end of 2000, and from 2001 the FP5 project Astrophysical Virtual Observatory – AVO was the basis for creation of European Virtual Observatory - EURO-VO (http://www.euro-vo.org).

SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) is a project created in 2008, with the objectives: a) Establishing SerVO and join the EuroVO and IVOA; b) Establishing SerVO data Center for digitizing, archiving and publishing in VO format photo-plates and other astronomical data produced at Belgrade Astronomical Observatory; c) Development of tools for visualization of data; d) Publishing, together with Observatoire de Paris, STARK-B - Stark broadening data base containing as the first step Stark broadening parameters obtained within the semiclassical perturbation approach by two of us (MSD-SSB) in VO compatible format; e) Make a mirror site for DSED (Darthmouth Stellar Evolution Database in the context of VO.

In order to enable an efficacious and convenient search for available atomic and molecular data, to build a secure, flexible and interoperable e-science environment based interface to the existing Atomic and Molecular databases and solve the existing problems in A&M data community, preventing productive search and data mining, the FP7 founded project Virtual Atomic and Molecular Data Center (VAMDC) started on July 1 2009. The core of the VAMDC e-infrastructure is the databases upon which it is based, and our contribution to the VAMDC e-infrastructure are the STARK-B database (http://stark-b.obspm.fr), a collaborative project between Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon and the Astronomical Observatory of Belgrade. This is a database of the theoretical widths and shifts of isolated lines of atoms and ions due to collisions with charged perturbers, obtained within the impact approximation.

We review here SerVO, STARK-B and VAMDC projects within the context of e-science in Astronomy – Astroinformatics.

Key words: *Virtual observatories, Astroinformatics, Atomic and Molecular data, Stark broadening*

INTRODUCTION

A number of scientific problems, like for example the modelling of stellar atmospheres and of the stellar interiors needs extensive sets of various input data, first of all atomic ones, and needs for larger and larger sets of data increase with the new possibilities provided by the development of computer technologies. E.g. the PHOENIX computer code [1] developed for stellar modelling includes a database containing more than 10^8 atomic, ionic and molecular spectral lines, which number is permanently increasing.

Especially the progress of satellite astronomy and large telescopes of new generation, enable to collect a huge amount of high quality astronomical data, produced an information avalanche and leaded to the creation of huge data collections as e. g. IUE and HST archive. For example Sloan Digital Sky Survey SDSS, contains spectra of ~ 230 million objects and the new 8.4-meter LSST telescope willl have the ability to survey the entire sky in only three nights. Software is one of the most challenging aspects of this project, since more than 30 Terabytes of data must be processed and stored each night in producing the largest non-proprietary data set in the world, of the Petabyte order.

CompSysTech'11, June 16–17, 2011, Vienna, Austria.

The problem is how to analyse such amount of data?

In order to address this problem, the idea of Virtual Observatory was formulated at the end of 2000, and from 2001 the FP5 project Astrophysical Virtual Observatory – AVO was the basis for creation of European Virtual Observatory - EURO-VO (http://www.euro-vo.org).

Today, Virtual observatories combine research in different areas of astrophysics, as multi-wavelength astrophysics, archival research, survey astronomy, temporal astronomy, theory and simulations (comparisons with observations) and information technology, digital detectors, massive data storage, the Internet, data representation standards...

In order to facilitate the international coordination and collaboration necessary for the development and deployment of the first of all the development of standards, and also tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory, International Virtual Observatory Alliance (IVOA, http://www.ivoa.net) was formed in June of 2002.

SerVO – SERBIAN VIRTUAL OBSERVATORY

SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) started as a project whose funding was approved through a grant TR13022 from Ministry of Science and Technological Development of Republic of Serbia [2], with duration of 33 months from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". After establishing SerVO and starting to digitize and archive photo plates [3] and other astronomical data produced at Belgrade Astronomical Observatory, the aims are: i) To work on the development of SerVO and to join the EuroVO and IVOA; b) To develop SerVO data Center which will work on the digitizing, archiving and publishing in VO format photo-plates; c) To work on the development of tools for visualization of data; d) Make a regional node of Virtual Atomic and Molecular Data Center – VAMDC; e) Make a mirror site of STARK-B - Stark broadening data base containing as the first step Stark broadening parameters obtained within the semiclassical perturbation approach by two of us (MSD-SSB) in VO compatible format; f) Make a mirror site for DSED - Darthmouth Stellar Evolution Database [4,5] in the context of VO.

The digitization and publication in VO of around 14,500 photo-plates archived on Belgrade Astronomical observatory, obtained between 1936 and 1996, as well as stellar catalogues produced in Serbia, and digitization of astronomical publications, is in progress. Our objective is that they become accessible by astronomical community through Serbian Virtual Observatory. The plates are preparing to enter in SerVO in collaboration with the Milcho Tsvetkov, Katya Tsvetkova and their team [3] who created Wide-Field Plate Database (http://www.skyarchive.org) in the Institute of Astronomy of Bulgarian Academy of Sciences in Sofia.

Informal collaboration in the wide-field plate archiving between Astronomical Observatory of Belgrade and the team of the WFPDB has existed since 1999. In 2004 a project entitled “Development and Application of Astronomical Databases” within the frame of the cooperation between Serbian and Bulgarian Academies (SANU and BAN) was signed between Astronomical Observatory of Belgrade and Space Research Institute of Bulgarian Academy of Sciences (where WFPDB was at that time) for the period 2004–2006. The work on the Belgrade observatory plates was continued within the frame of the new project between Astronomical Observatory of Belgrade and Institute of Astronomy of Bulgarian Academy of Sciences, signed for a period 2007–2009, and renewed in 2011.

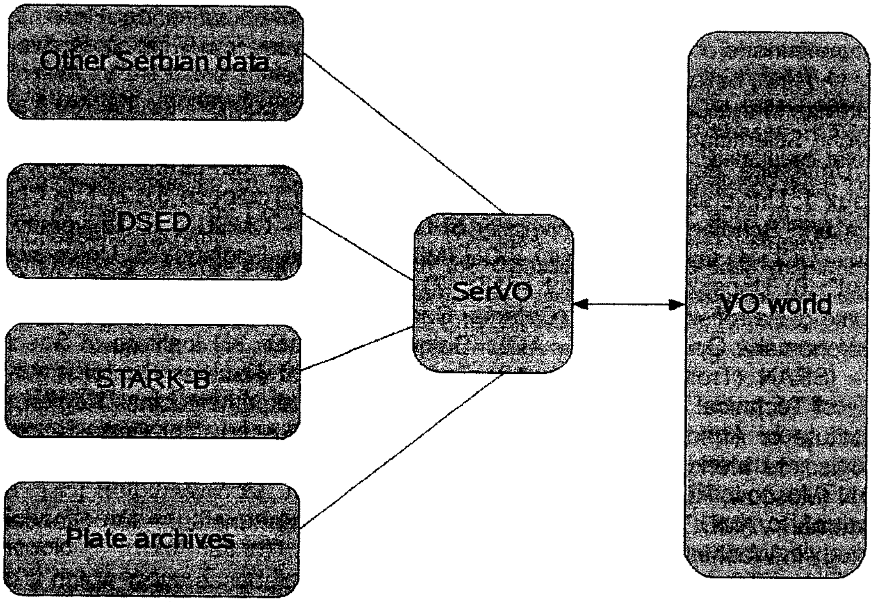

Fig. 1 Content of Serbian Virtual Observatory

VAMDC – VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Atomic and Molecular data in existing databases are organized and presented in different ways, with different standards, rules and selection criteria, with sometimes overlapping efforts which is an obstacle for an efficacious and convenient search for such data and their adequate use. One could enumerate the main existing problems preventing search of A&M data and data mining as: a) Lack of standards and common guidelines; b) Interoperability problem. c) Data exchange problem. d) Overlapping of efforts; e) Need of hiring computer engineers since the majority of developers are Astronomers, Physicists, Chemists... f) Data identification problem (namely lack of completely adequate XML schemata keys for data identification); g) Need for a critical evaluation of data.

We can also add that for a number of scientific problems, it is very important to know who is producer of the data and the method and details of their production in order to estimate possible errors and accuracies of obtained results. Also in some databases data are "anonymous" so that their producers have not an adequate credit for their efforts.

The need to solve existing, above enumerated problems in A&M data community, and to provide facilities for a productive search and data mining, leaded to the VAMDC Idea, with the objective to create search engines that must look "everywhere" in order to map A&M Universe and to provide an accessible and interoperable e-infrastructure for A&M data. An additional aim is the creation of a forum of data producers, data users and databases developers, as well as the training of potential users..

In order to perform the above mentioned objectives and solve the enumerated problems, Virtual Atomic and Molecular Data Centre (VAMDC – [6]), a FP7 founded project, started on July 1 2009 with budget of 2.9 MEuros over 42 months.

The VAMDC will build a secure, documented, flexible, easily accessible and interoperable e-infrastructure for A&M data that on the one hand can directly extract data from the existing depositories, while on the other hand be sufficiently flexible to be tuned to the needs of a wide variety of users from academic, governmental, industrial communities or by the general public.

Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela.

Partners in the Consortium of the Project are: 1) The coordinator, Centre National de Recherche Scientifique - CNRS (Université Pierre et Marie Curie, Paris; Observatoire de Paris; Université de Reims; Université Joseph Fourier de Grenoble, Université de Bordeaux 1: Université de Bourgogne, Dijon; Université Toulouse 3); 2) The Chancellor, Masters and Scholars of the University of Cambridge – CMSUC; 3) University College London – UCL; 4) Open University – OU (Milton Keynes, England); 5) Universitaet Wien - UNIVIE; 6) Uppsala Universitet – UU; 7) Universitaet zu Koeln – KOLN; 8) Istituto Nazionale di Astrofisica – INAF (Catania, Cagliari); 9) Queen's University Belfast – QUB; 10) Astronomska Opservatorija - AOB (Belgrade, Serbia); 11) Institute of Spectroscopy RAS – ISRAN (Troitsk, Russia); 12) Russian Federal Nuclear Center - All-Russian Institute of Technical Physics - RFNC-VNIITF (Snezhinsk, Chelyabinsk Region, Russia); 13) Institute of Atmospheric Optics - IAO (Tomsk, Russia); 14) Corporacion Parque tecnologico de Merida – IVIC (Merida, Venezuela); 15) Institute for Astronomy RAS - INASAN (Moscow, Russia).

External VAMDC partner is also NIST – National Institute for Standards and Technology in Washington.

The core of the VAMDC e-infrastructure are the databases upon which it is based. The databases which enter in in the VAMDC project, representing the basis of its e-infrastructure are the following:

VALD database [7] of atomic data for analysis of radiation from astrophysical objects (http://vald.astro.univie.ac.at/); CHIANTI [8], an atomic database for spectroscopic diagnostics of optically thin collisionally ionised astrophysical plasmas (http://sohowww.nascom.nasa.gov/solarsoft, http://www.damtp.cam.ac.uk/user/astro/ chianti/); EMol Database [9], at the Open University in Milton Keynes, containing a comprehensive listing of critically evaluated and regularly updated measured and calculated cross sections for electron interactions with molecular systems; CDMS - Cologne Database for Molecular Spectroscopy (http://www.ph1.uni-koeln. de/ vorhersagen/) (It is cross correlated with its US counterpart, the JPL Jet Propulsion Laboratory Submillimeter Catalogue (http://spec.jpl.nasa.gov/) [10]); BASECOL database [11] (http://basecol.obspm.fr) containing excitation rate coefficients for ro-vibrational excitation of molecules by electrons, He and H_2; GhoSST (Grenoble astrophysics and planetology Solid Spectroscopy and Thermodynamics, http://ghosst.obs.ujf-grenoble.fr), offering spectroscopic laboratory data on molecular and atomic solids and liquids from the near UV to the far-infrared; UMIST - University of Manchester Institute of Science and Technology (UMIST) database for astrochemistry [12,13] (http://www.udfa.net/), providing reaction rate data and related software for chemical kinetic modelling of astronomical regions; KIDA - KInetic Database for Astrochemistry containing data on chemical reactions used in the modelling of the chemistry in the interstellar medium and in planetary atmospheres (http://kida.obs.u-bordeaux1.fr); PAHs (Polycyclic Aromatic Hydrocarbon) and carbon clusters spectral database (http://astrochemisty.ca.astro.it/database/) in Cagliari [14]; LASP (Laboratorio di Astrofisica Sperimentale) Database (http://web.ct.astro.it/weblab/ dbindex.html#dbindex) at the INAF (Istituto Nazionale di Astrofisica) - Catania Astrophysical Observatory, containing (i) infrared (IR) spectra of molecules in the solid phase for both pure species and their mixtures before and after processing with energetic ions and UV photons [15, 16, 17] (ii) IR optical constants of molecules in the solid phase and after processing with energetic ions [18, 19]; (iii) band strengths of the IR absorption bands [20, 21]; and (iv) density values of frozen samples [21,22]; Spectr-W^3 [23] atomic database (http://spectr-w3.snz.ru), listing experimental, calculated, and compiled data on ionization potentials, energy levels, wavelengths, radiation transition probabilities and oscillator strengths, and also parameters for analytic approximations for electron-collision cross-sections and rates for atoms and ions; CDSD - The Carbon Dioxide Spectroscopic Databank [24] (http://cdsd.iao.ru and ftp://ftp.iao.ru/pub/CDSD-2008), containing calculated spectral line parameters for seven isotopologues of carbon dioxide; S&MPO - Spectroscopy & Molecular Properties of Ozone) relational database [25] (http://ozone. iao.ru and http://ozone.univ-reims.fr/), containing spectral line parameters for the ozone molecule, experimental UV cross-sections, information on ozone's molecular properties, updated reference lists as well as programs for user applications; "Spectroscopy of Atmospheric Gases" (http://spectra.iao.ru), containing databases HITRAN [25], GEISA [26] and HITEMP [27]; W@DIS - Water Internet @ccessible Distributed Information System (http://wadis.saga.iao.ru), listing experimental water-vapour spectroscopy data; TOPbase [28] located at the Centre de Données astronomiques de Strasbourg, France (http://cdsweb.u-strasbg.fr/topbase/home.html), containing TOPbase (http://cdsweb.u-strasbg:fr/topbase/ topbase.html), listing atomic data computed in the Opacity Projec, TIPbase (http://cdsweb.u-strasbg.fr/tipbase/home.html), with atomic data computed by the IRON Project, and OPserver [29], located at the Ohio Supercomputer Center, USA, (http://opacities.osc.edu/), a remote, interactive server for the computation of mean opacities for stellar modelling using the monochromatic opacities computed by the Opacity Project.

Within VAMDC e-infrastructure are also: XSTAR database [30], used by the XSTAR code (http://heasarc.gsfc.nasa.gov/ docs/software/ xstar/xstar.html) for modelling photoionised plasmas; HITRAN - HIgh-resolution TRANsmission molecular absorption database [25] (http://www.cfa. harvard.edu/hitran/) and GEISA - Gestion et Etude des Informations Spectroscopiques Atmosphériques (Management and Study of Atmospheric Spectroscopic Information) database [26] (http://ara.lmd.polytechnique. fr/index.php?page=geisa-2 or http://ether.ipsl.jussieu.fr/etherTypo/?id=950); HITEMP, a high temperature extension to HITRAN [27] (To access the HITEMP data: ftp to cfa-ftp.harvard.edu; user = anonymous; password = e-mail address); STARK-B database (http://stark-b.obspm.fr) [31] of the theoretical widths and shifts of isolated lines of atoms and ions due to collisions with charged perurbers, obtained within the impact approximation.

The VAMDC facilities will be first of all useful for Astronomy, Plasma science, Atmospheric Science Radiation science and Fusion community as well as Industries using technological plasmas and Lightning industry and will represent a powerful tool for a better and easier search for the needed atomic and molecular data and an efficace data mining.

STARK-B DATABASE

The database STARK-B is a collaborative project between Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon and the Astronomical Observatory of Belgrade. For the moment STARK-B contains Stark line broadening parameters (widths and shifts) obtained within the impact approximation using the semiclassical perturbation approach [32,33]. The computer code, developed according to Refs. [32,33], has been optimized and updated in Refs. [34, 35, 36] and following papers. All updates are described for example in Ref. [37].

STARK-B is devoted for modelling and spectroscopic diagnostics of stellar atmospheres and envelopes, as well as for laboratory plasmas, laser equipment, inertial fusion plasma and technological plasmas. So, the domain of temperatures and densities covered by the tables is wide and depends on the ionization degree of the considered ion. The temperature can vary from several thousands for neutral atoms to several millions of Kelvin for highly charged ions. The electron or ion density can vary from 10^{12} (case of stellar atmospheres) to several 10^{22} cm^{-3} (some white dwarfs, subphotospheric layers and some laboratory and fusion plasmas). The accuracy of the data varies from about 15-20 percent to 35 percent, and in some cases up to 50 percent depending on the degree of excitation of the upper level, on the completeness of the set of perturbing energy levels, and on the quality of the used atomic structure entering the calculation of scattering S-matrix leading to the widths and shifts. The more the upper level is excited, the more the accuracy is good. The database is currently developed in Paris, and a mirror is planned in Belgrade. It is on line though not yet complete.

Actually, STARK-B contains Stark broadening parameters for spectral lines of He I, Li I, Li II, Be I, Be II, Be III, B II, B III, C II, C III, C IV, C V, N I, N II, N III, N IV, N V, O I, O II, O IV, O V, O VI, O VII, F II, F III, F V, F VI, F VII, Ne I, Ne II, Ne III, Ne V, Ne VIII, Na I, Na IX, Na X, Mg I, Mg II, Mg XI, Al I, Al III, Al XI, Si I, Si V, Si VI, Si XI, Si XII, P IV, P V, S III, S IV, S V, S VI, Cl VII, Ar I, Ar II, Ar VIII, K I, K VIII, K IX, Ca I Ca II, Ca IX, Ca X, Sc III, Sc X, Sc XI, Ti IV, Ti XI, Ti XII, V V, V XIII, Cr I, Cr II, Mn II, Fe II, Ni II, Zn I, Ga I, Ge vI, Se I, Kr I, Kr II, Kr VIII, Rb I, Sr I, Y III, Ag I, Cd I, Cd II, In II, In III, Te I, Ba I, Ba II, Au I, Hg II, Tl III, and Pb IV.

The predecessor of STARK-B and SerVO was BELDATA database started to be developed on Astronomical Observatory in Belgrade, which main content were Stark broadening parameters. The history of the work on BELDATA can be found in Refs. [38, 39, 40, 41, 42, 43].

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić. Besides the close colaboration of more than 30 years between two of us (MSD and SSB), we also collaborate with Nebil Ben Nessib, Walid Mahmoudi, Rafik Hamdi, Haykel Elabidi, Besma Zmerli and Neila Larbi-Terzi from Tunisia, and Magdalena Christova from Technical University of Sofia.

CONCLUSIONS AND FUTURE WORK

We plan to further develop and improve STARK-B database. After finishing the including of existing semiclassical perturbation results for Stark broadening of spectral lines, for the cases where such results do not exist, we will start to include data obtained with simpler methods. In a future version we plan to include and selected experimental results.

Work on SerVO is also in progress and we hope to enter soon in IVOA.

VAMDC is an example of the global collaborations and development of new facilities in e-science. It is expected to become one of the major European cyber-infrastructures with a world wide impact; some kind of a Google for atomic and molecular data. We plan to develop further the Serbian VAMDC node with an aim to become a regional center for this activity, organizing trainings for students and potential users and monitoring the needs of users in South Eastern Europe.

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SOFIA UNIVERSITY ST. KLIMENT OHRIDSKI
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CONTEMPORARY ASPECTS OF ASTRONOMY, THEORETICAL AND GRAVITATIONAL PHYSICS

Dedicated to Georgi Ivanov Manev (1884 - 1965)
Professor in Theoretical Physics

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PROGRAMME AND ABSTRACTS

Serbs and Astronomy in XVIII and XIX Century

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Astronomical activities of Serbs and others in Serbian territories during XVIII, XIX century and the bigining of the XX century uo to the First world war are discussed. In the considered period, Rudjer Boskovic from Dubrovnik, works as a scientist on astronomy. He investigates different astronomical problems, develops his theory on atoms and founds the Brera observatory in Milan. Besides the theoretical work in the research field of astronomy, Rudjer Boskovic also observes.

Astronomical observations from Serbian countries performs also a count from Bologna Luigi [Aloysius] Ferdinandus Marsigli (1658-1730). Great traveller, poet, theologue and at the end archimandrit Jovan Rajic (11. XI 1726 - 11. XII 1801) teaches astronomy in so called Latin school in Sremski Karlovci since 1749 up to 1768. He observes as well, and his description of observations of a comet from 1769 is preserved.

On the interest for astronomy witness also different translations and alterations of texts concerning this science. Besides, astronomical contents may be found in calendars, which start to be printed in Serbian in the second half of the eighteenth century. The scientific life in Serbian countries at the end of the eighteenth and the beginning of the nineteenth century is denoted by the "enlightener" spirit of Dositej Obradovič. For him, the science was as the first a mean to enlighten the people and to suppress the superstition.

The most important among writers who followed such views of Dositej was Atanasije Stojkovic (1733-1832), doctor of phylosophy and fellow of German scientific societies. From 1801 up to 1803 he publishes the first modern Serbian text-book on Physics. On 1803 he was elected for professor of physics at Kharkov University. There he writed his most important works as for example book on meteorites "O vozdushnykh kamnyakh i ikh proiskhozhdenii" (On air stones and their origin) 1807.

In the second half of the nineteenth century has been created a basis permitting that astronomy becomes a real science and finds his place in secondary schools and in Grand School. In this period Astronomical and Meteorological Observatory has been founded in 1887, as well as the Chair for Astronomy and Meteorology. In this period are published the first scientific articles in the nowadays sense, the first textbooks and begins to develop the amateur astronomy. The important persons are Vuk Marinkovic (1807 - 1859), Djordje (Gavrilo) Popovic (1811 Baja - 1871 Beograd), who publishes in 1850 the book "Astronomija ili nauka o zvezdama" (Astronomy or the science about stars), one of the first amateur astronomer in Serbian countries, Jovan (Julijan) Cokor (21.01/2.02 1810 Baja - 1/13.06 1871 Sremski Karlovci), who made in Sremski

Karlovci a little observatory and produced also sun-dials, Lazar Komarcic writer of the first serbian science fiction novel Jedna ugasena zvezda (1902), Jelenko M. Mihajlovic (January 11, 1869 Vrbica near Knjazevac - October 30, 1956, Belgrade). the founder of modern Serbian seismology, the author of the numerous textbooks and popular articles, concerning also spectroscopy and photography in astronomy and cousins Ivan and Ilija Milosevic. Of interest for the history of astronomy of this period are also investigations of meteorites by Josif Pancic (Soko-Banja the first meteorite in Serbia) and Jovan Zujovic (The meteorite of Jelica).

Also will be considered Stevan Boskovic and astrogeodetical determinations in the kingdom of Serbia, Milan Nedeljkovic (Belgrade 27. Sept. 1857 - Belgarde 27 Dec. 1950) and the foundation of Belgrade astronomical observatory and the Chair for astronomy and meteorology and Djordje Stanojevic (Negotin, 7 April 1858 - Paris 24 Dec. 1921) and the first astrophysical scientific articles by a Serbian author.

Extended Objects in Minkowski Space-Time

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Extended objects in Minkowski space-time are those the components of which are described by spatially finite or spatially localized functions, and the time-dependence is determined additionally, e.g. by some dynamical equations. We consider various physically sensible examples of such objects: functions, vector fields, 1-forms, 2-forms, vector valued differential forms; and give corresponding physical interpretations through defining dynamical equations and appropriate energy-momentum tensors. The case of 2-form (Maxwell field) is considered in more detail, and spatially finite photon-like solutions with rotational component of propagation are given. An extended concept of parallelism, allowing natural extension/nonlinearization of some used in physics equations, is introduced and examples are considered.

The Gravitational Field of Massive Point Particle in General Relativity

Plamen Fiziev

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Utilizing various gauges of the radial coordinate we give a description of static spherically symmetric space-times with point singularity at the center and vacuum outside the singularity. We show that in general relativity (GR) there exist a two-parameters family of such solutions to the Einstein equations which

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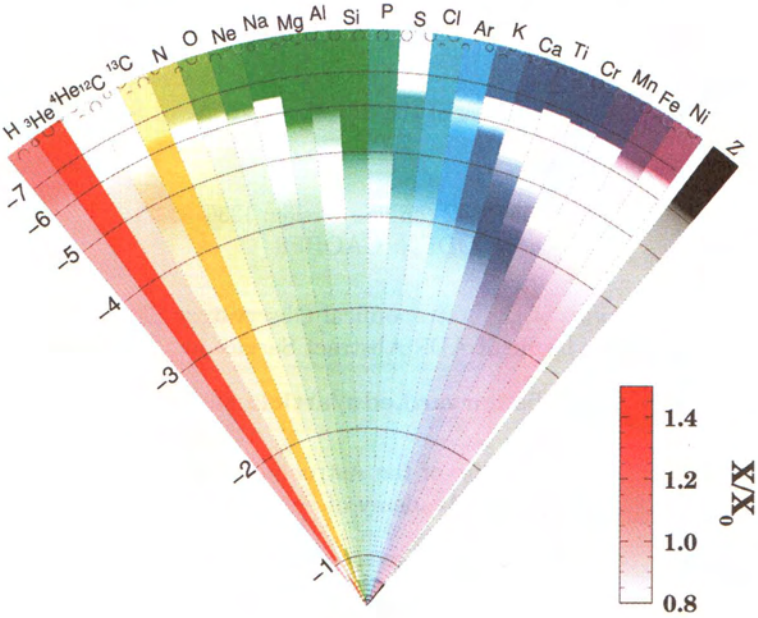

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Electron-impact broadening of ionized chromium lines for Ap star atmospheres analysis

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Abstract. The influence of Stark broadening on the shapes of Cr II spectral lines observed in stellar atmospheres is considered.

Key words: stars: chemically peculiar – stars: atmospheres – line: formation – line: profiles – atomic processes – atomic data.

1. Introduction

Chromium is one of the most peculiar elements in the atmospheres of magnetic chemically peculiar stars. In order to provide the atomic data required to calculate lines profiles of this element, we have calculated Stark widths and shifts for the strongest Cr II multiplets. The calculations were performed within the semi-classical perturbation formalism after Sahal-Bréchot (1969 a, b). Our results for seven Cr II multiplets are shown in Table 1 of Dimitrijević *et al.* (2007). The results obtained are used to analyze the contribution of Stark broadening in CP star spectra, and here an example of the analysis of Dimitrijević *et al.* (2007) is given.

2. Results and discussion

It is not possible to check Stark damping constants using the spectra of the normal stars. No Cr II lines in the entire optical region are sufficiently strong to show substantial Stark wings in hotter stars, while in cooler stars (the Sun for example) the van der Waals effect is absolutely dominant. Therefore we can investigate the Stark broadening effect only in the spectra of chemically peculiar (Ap) stars.

As an example we chose the Ap star HD 133792, with $T_{\rm eff}$ = 9400 K, $\log g$ = 3.7, and a mean Cr overabundance of +2.6 dex relative to the Sun. We used a spectrum retrieved through the ESO archive, and all calculations were carried out with the SYNTH3 code (Kochukov, 2006) for synthetic spectrum determinations. All details of the calculations are given by Dimitrijević *et al.* (2007).

A good agreement between observations and calculations for weak Cr II lines demonstrates the existence of a stratified Cr distribution, while four strong Cr II lines demonstrate a good accuracy of the Stark constants obtained in the present work. Figure 1 shows a comparison between the observed line profiles of three Cr II lines and our synthetic calculations.

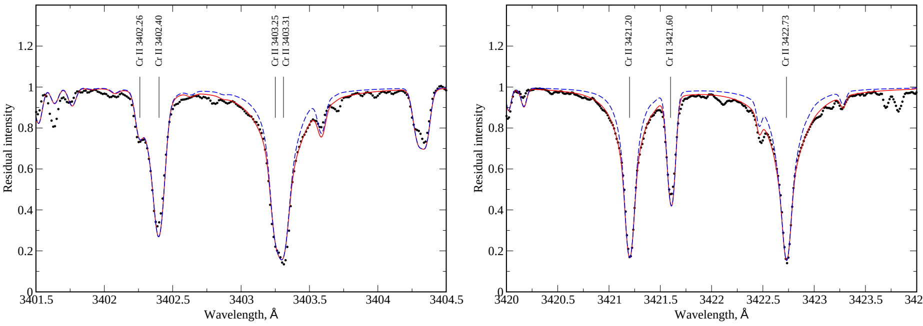

Figure 1. Comparison between the observed Cr II 3403.30 (**left**) and 3421.20, 3422.73 Å (**right**) line profiles (dots) and synthetic calculations with the Stark parameters from the present paper (full line) and those from Kurucz (1993) (dashed line).

We may conclude also that the line wings of Cr II lines in spectra of Ap stars are caused by the Stark-broadening mechanism.

In the end, we note that new Stark parameters are particularly important for the study of Cr stratification in Ap stars in the 9000 − 10 000 K temperature range, where this stratification may be obtained only from a careful study of the line profiles of multiplet 3 Cr II lines, whose Stark broadening parameters are analyzed here and shown by Dimitrijević *et al.* (2007).

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On the Stark broadening of Te I spectral lines for CP star plasma analysis

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Abstract. By using the semiclassical perturbation method, Stark widths and shifts have been calculated for the Te I 6s ^{5}S^o - 7p ^{5}P (5125.2 Å) multiplet, of interest for CP star plasma studies. Results were applied to the investigation of the influence of Stark broadening on CP star spectra. It was found that layers exist in the stellar atmospheres considered where the Stark broadening contribution is comparable to or larger than the Doppler width.

Key words: stars: chemically peculiar – stars: atmospheres – line: formation – line: profiles – atomic processes – atomic data

1. Introduction

With the development of astronomical observations from space, even elements like tellurium can now be identified in stellar spectra. For example, Yuschenko and Gopka (1996) identified one line of tellurium in the photospheric spectrum of Procyon, and Chayer *et al.* (2005) observed Te I spectral lines in UV spectra of the cool DO white dwarf HD 199499. In order to provide the necessary line broadening data, we have recently calculated Stark broadening parameters for four Te I multiplets for plasma conditions of interest for CP stars. We present here the results for the Te I 6s ^{5}S^o - 7p ^{5}P multiplet and use them for the analysis of the influence of Stark broadening for CP star plasmas by comparing Stark and Doppler widths in model stellar atmospheres.

2. Results and discussion

Calculations have been performed within the semiclassical perturbation formalism, developed and discussed by Sahal-Bréchot (1969 a, b). For updates see e.g. Dimitrijević (1996). All details of the calculations will be given by Dimitrijević *et al.* (in preparation). Here, as an example, we present electron- and proton-impact broadening parameters for the Te I 6s ^{5}S^o - 7p ^{5}P (5125.2 Å) multiplet

Table 1. Electron (e^-) and proton (p^+) impact full widths at half maximum (W) and shifts (d) for the Te I 6s $^5S^o$ - 7p ^5P multiplet for an electron density of 10^{16}cm^{-3}.

TRANSITION	T[K]	W_e^- [Å]	d_e^- [Å]	W_p^+ [Å]	d_p^+ [Å]
	5 000	0.146	0.912E-01	0.842E-01	0.215E-01
	10 000	0.170	0.944E-01	0.855E-01	0.251E-01
6s $^5S^o$ - 7p ^5P	20 000	0.196	0.894E-01	0.865E-01	0.288E-01
5125.2 Å	50 000	0.230	0.638E-01	0.880E-01	0.341E-01
	100 000	0.244	0.515E-01	0.895E-01	0.387E-01
	150 000	0.243	0.435E-01	0.906E-01	0.414E-01

for a perturber density of 10^{16}cm^{-3} and temperatures from 5×10^3 K to 1.5×10^5 K (Table 1).

The Stark widths obtained have been compared with Doppler widths for A-type stellar atmosphere models (Kurucz, 1979; Fig. 1). Our results are presented as a function of Rosseland optical depth. One can see that there exist layers in these atmospheres where Stark broadening is comparable to or even larger than Doppler broadening.

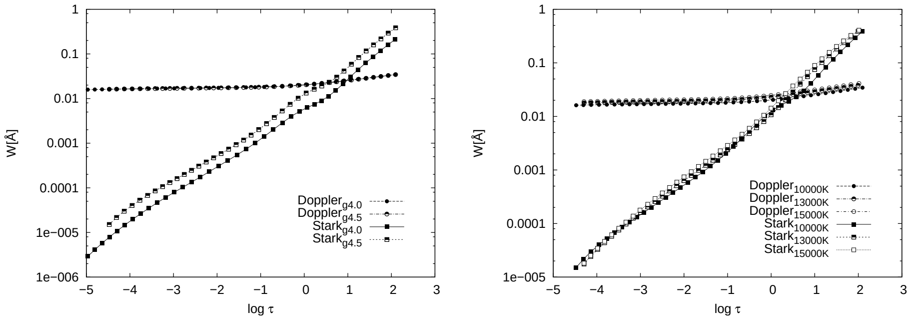

Figure 1. Thermal Doppler and Stark widths for the Te I 6s $^5S^o$ - 7p ^5P (5125.2 Å) multiplet as a function of optical depth, $T_{\rm eff}$ and $\log g$, for A type stars. Left: $T_{\rm eff} = 10\,000$ K, $\log g = 4.0 - 4.5$; right: $T_{\rm eff} = 10\,000 - 15\,000$ K, $\log g = 4.5$.

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On Stark broadening of Mn II lines in Ap-star conditions

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Abstract. Stark broadening parameters for six Mn II lines are determined semi-classically and used to analyse the influence of this broadening mechanism on A-type star spectral line profiles. Results for the Mn II line at 2950.1 Å are presented here as an example of the data obtained.

Key words: line: formation – line profiles – atomic data – stars: atmospheres.

1. Introduction

Stark broadening of ionised manganese lines is of interest for the analysis and modelling of stellar spectra of, for example, HgMn stars (Wahlgren, Hubrig 2004). We calculated Stark broadening parameters for six Mn II lines within semi-classical perturbation theory (Sahal-Bréchot, 1969 a) and used them for the analysis of the influence of Stark broadening on A-type star spectral line profiles. Here we present as an example results for the Mn II line at 2950.1 Å.

2. Results and discussion

The results were obtained within the semi-classical perturbation formalism, developed and discussed in detail in Sahal-Bréchot (1969 a, b), and all details of the calculations will be given in Popović *et al.* (2008).

In Table 1, electron-impact broadening parameters (full width at half maximum W and shift d) for the Mn II line at 2950.1 Å for a perturber density of 10^{17}cm^{-3} and temperatures from 5000 to 100 000 K, are given.

The results obtained are used to compare the thermal Doppler and Stark widths of the Mn II spectral line a^5S–z^5P^o 2950.1 Å as a function of the Rosseland optical depth for a Kurucz (1979) model of an A star with $T_{\text{eff}} = 10\,000\,\text{K}$, $\log g = 4.5$. As one can see, Stark broadening may be of interest in deep sub-photospheric layers. One should take into account that even when Stark width is smaller, this effect might be important in the far line wings.

Table 1. Electron-impact broadening parameters (full width at half maximum W and shift d in Å). The first set of values is calculated including the estimated maximal contribution of forbidden transitions. The second set of values, denoted by ($'$), is calculated taking into account only dipole-allowed transitions.

Transition	T[K]	$W_{\rm e}$ [Å]	$d_{\rm e}$ [Å]	$W_{\rm e}^{'}$ [Å]	$d_{\rm e}^{'}$ [Å]
	5 000	0.226	-0.394E-01	0.176	-0.653E-03
	10 000	0.165	-0.302E-01	0.130	-0.253E-02
a ^{5}S - z ^{5}P^o	20 000	0.121	-0.234E-01	0.969E-01	-0.258E-02
2950.1 Å	30 000	0.102	-0.193E-01	0.830E-01	-0.209E-02
	50 000	0.884E-01	-0.168E-01	0.713E-01	-0.282E-02
	100 000	0.800E-01	-0.137E-01	0.619E-01	-0.257E-02

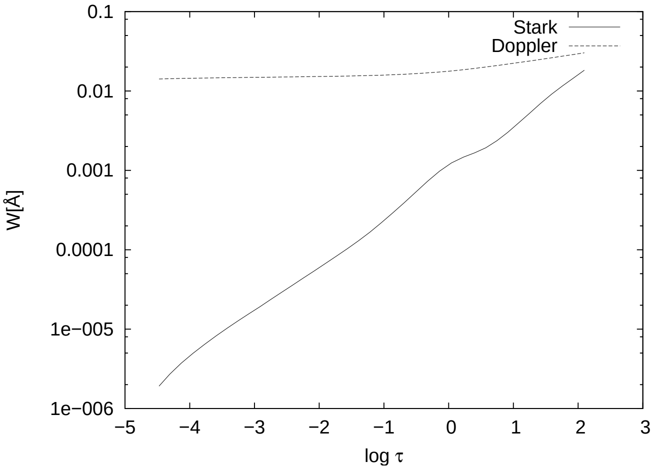

Figure 1. The thermal Doppler and Stark widths for the Mn II spectral line a^{5}S–z^{5}P^o 2950.1 Å as a function of Rosseland optical depth, $T_{\rm eff} = 10\,000$, $\log g = 4.5$.

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ABSTRACTS

Particle transport phenomena in CP stars

J. Budaj

Calculations of radiative accelerations (RA) as well as implied abundance anomalies (or stratification) are described and briefly summarized. It is found that stimulated emission is significant and should be included in RA. New "turbulent" model is proposed for atmospheres of Hg-Mn stars based on abundance independent RA calculations so far. However, it requires more detailed calculations at least for two elements. Mixing due to microturbulence, sound waves, p-modes is investigated. Results imply that no stratification due to diffusion should be observed in roAp stars.

What is the reason for the Am phenomenon?

J. Budaj

Some constraints are put for short period binaries with CP components (mainly Am). Rate of mixing due to tidal forces was estimated considering an asynchronic rotation of an Am star. It is found that diffusion is allowed to take place only if orbital periods are larger than 10^2 days.

Stationary Diffusion of Al in a "Turbulent" Model of an Hg-Mn star

J. Budaj, M. Zboril, J. Zverko, J.Žižnovský, J. Klačka

The investigation of the stacionary state of the stratification of Al under the turbulence proposed by a "turbulent" model is investigated. Equation of the stationary state is solved under several simplifications. Al is predicted to be generally underabundant with the tendency of increasing abundance with decreasing effective temperatures of the stars.

Stark broadening data for stellar plasma research

M. S. Dimitrievič

Stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters, needed for e.g. stellar plasma investigation and abundance determination. With the development of space astronomy, the interest of a very extensive list of line broadening data is additionaly stimulated. Here is presented a review of semiclassical calculations of stark broadening parameters and comparison of different semiclassical procedures is discussed, as well as the agreement with critically selected experimental data and more sophisticated, close coupling calculations. The astrophysical interest of Stark broadening research is discussed as well.

A static, spherically symmetric NLTE model atmosphere of an A star using approximate lambda operators. First results

J. Kubát

We present results of a static spherical NLTE model atmosphere calculation for a star with $L = 5.12 \times 10^2 L_\odot$, $M = 6.65 M_\odot$, and $R = 4.24 R_\odot$ ($T_{\rm eff} = 10644K$, $\log g = 3.42$). The calculation is performed by a recently developed computer code ATA. This code is based on an accelerated lambda iteration (ALI) and is applicable for calculations of static spherically symmetric NLTE model atmospheres in hydrostatic and radiative equilibrium.

ABUNDANCE ANALYSIS OF COOL OSCILLATING CP STARS:
Alpha Circinis, Gamma Equulei and HD 24712

F. Kupka, T. Ryabchikova, G. Bolgova, R. Kuschnig, W.W. Weiss

After an extensive abundance study of 21 cool CP stars made by S. Adelman twenty years ago, new determinations for other stars of this peculiarity group were very rare. Few of the cooler CP stars are found to be pulsating. One needs to know accurately the atmospheric structure and abundances of these stars, as boundary conditions for modelling the pulsation. We present preliminary results of our abundance analysis for three cool rapidly oscillating CP stars, based on high S/N CCD and Reticon spectra and using the spectrum synthesis technique. All three stars, Alpha Cir, Gamma Equ and HD 24712, have normal or slightly deficient abundances of Fe-peak elements and overabundance of rare-earth elements. Barium seems to be normal or even deficient, while overabundance of Sr-Y-Zr has been found. REE sequence does not show any significant violation of odd-even effect. All three roAp stars show less peculiar abundances compared with the cool CP star Beta CrB, for which presently no pulsation is detected.

THE PECULIAR BINARY SYSTEM ET And II: Atmospheric Parameters and Abundances

R. Kuschnig, T. Ryabchikova, N. Piskunov, W.W. Weiss, F. Kupka, J.M. Le Contel

For the B9p primary component of the peculiar binary system ET And the atmospheric parameters are derived using different photomeric calibrations and theoretical hydrogen line profiles adopted from the most recent ATLAS 9 models. Comparison of these theoretical profiles with high S/N CCD observations gives $T_{\rm eff} = 11500K$, $\log g = 3.6$ wich indicates that this star is within the main sequence band. The abundance analysis based on the spectrum synthesis in different spectral regions distributed in the 4000 - 6600 Åinterval shows a great Si overabundance up to 2 dex but no significant enhancement for Fe-peak elements.

The influence of ion-atom radiative collisions to the opacity in helium rich DB white dwarfs

A. A. Mihajlov, M. S. Dimitrievič

We investigate the influence of radiative processes due to $He^+(1s) - He(1s^2)$ collisions on the continuum optical spectrum of He- rich DB white dwarf atmosphere. We show that these ion-atom radiative collisions processes are important in certain layers of the studied white dwarf atmosphere, although the total contribution to the continuous opacity is small

On stark broadening of heavy ion lines in spectra of Cp stars: SbII lines

L.C.Popovič and M.S.Dimitrijevič

Strong absorption of heavy ion lines have been observed in spectra of Cp stars as e.g. SbII spectral line ($\lambda = 1436.49 \mathring{A}$) in spectra of HR7775 and $\iota CrB(HgMn)$ stars (Jacobs and Dworetsky 1982). Since the electron density in layers where the SbII lines are formed is $10^{20} - 10^{21} cm^{-3}$ it is of interest to provide the corresponding Stark broadening data wich might be of significance for the analysis of stellar spectra.

Here we present Stark broadening data for five SbII multiplets ($5s^2 5p - 5s5p^3 3D^0, 5s^2 5p623P - 6s^3 P^0, 6s^3 P^0 - 6p^3 D, 6s^3 P^0 - 6p^3 P, 6s^3 P^0 - 6p^3 S$) as a function of temperature. Stark broadening data are calculated within modified semi empirical approach (Dimitrijevic and Konjevic 1980, Dimitrijevic and Krsljanin 1986) for electron density of $10^{23} m^{-3}$. Our results have been compared with available experimental data (Puric et al. 1985). Taking into account the complexity of the SbII spectrum, our results satisfactory agree with experimental data.

Non-uniform spatial distribution of non-reversive CP stars

J.Romanyuk

The predominantly dipole character of the stellar magnetic field enables one to analyse the distribution of the angles between the magnetic and rotational axes. So far no studies of the distribution of the sign of the longitudinal component, B_e, have been published. The sign of the longitudinal field is determined by the conditionally taken "zero-point". There is no reason to expect any diferencees of spatial distribution of fields with a different sign.

We have selected 64 non-reversive CP stars: 28 with dominantly "+" sign and 36 - with dominantly "-" sign of B_e from Babcock's, Landstreet et al. and our measurements.

Results. CP "+" stars are distributed uniformly along the galactic longitude, while CP "-" stars were not found in two opposite longitude intervals $l = 220^o - 290^o$ and $20^o - 120^o$.

Various factors affecting the measurements are analyzed. The comparison of the photographic and the photoelectric magnetic field measurements shows no shifts of "zero-points" (i.e. no false magnetic fields). Additional observations are needed to find out if the non-uniformity in the spatial distribution is real, or is affected by the small number of data used.

ATOMIC DATA FOR STELLAR SPECTROSCOPY

T. A. Ryabchikova

Spectrum synthesis becomes one of the more powerful methods for stellar abundance determinations due to the developpment of high resolution and high signal-to-noise detectors for spectroscopic observations. It requires more accurate and extensive atomic data. We present a short review of available oscillator strength systems together with some remarks about their accuracy and reliability.

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ABSTRACT BOOK

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Posters

P01: The Bolometric Correction of the peculiar pulsating star Alpha Cir

I. Brandão [1] & M.S. Cunha [1]

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Alpha Cir (HD128898) is the prototype of a class of Ap stars that oscillate in high frequencies. The combination of classical and seismic data of these stars can contribute greatly to the understanding of their structure and evolution. In order to place alpha Cir in the Hertzsprung-Russell (HR) diagram, both effective temperature and luminosity are needed. Since the parallax of the star was measured by Hipparcos, the luminosity can be derived if the apparent bolometric flux is known. Moreover, the apparent bolometric flux can also be used to determine the effective temperature of alpha Cir, if a measurement of its angular diameter is available. In principle, the bolometric flux can be determined from the visual flux if the bolometric correction is known. However, bolometric corrections for normal stars cannot be used when studying Ap stars, since the latter show abnormal flux distributions, with strong flux deficiencies in the ultraviolet relative to normal stars with the same Paschen slope. With this in mind, we have used spectroscopic and photometric data of alpha Cir available in the literature to determine the star's bolometric correction. Two values were determined, both based on an estimation of the total integrated flux of this star. The first result was determined by combining the observed ultraviolet flux (taken from IUE low dispersion spectrum) and the Kurucz model that best fitted the optical and NIR photometry for the star. A second value for the bolometric correction was computed using the same method, but substituting the Kurucz synthetic spectra by the mean of two low resolution spectra of alpha Cir calibrated in flux. A discussion of the two values obtained and their associated uncertainties is provided.

P02: Synthetic spectra of HgMn stars compared with UVES spectra

F. Castelli [1], & S. Hubrig [2]

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Results of the spectral analyses of some HgMn stars observed with UVES at high resolution and high S/N are available online in the form of plots of the overimposed observed and LTE computed spectra. The online material is available at http://wwwuser.oat.ts.astro.it/castelli/stars.html. The studied ranges are divided into 6 Å wide intervals having identifications, excitation potential of the lower level, and predicted line intensities written above the lines. Complete analyses covering the 3050-9500 Å region have been performed for two stars, HD 175640 and HR 6000. Preliminary analyses of some specific spectral ranges are available for a few other stars (i.e. 46 Aql, Feige 86). The online plots show the quality of the agreement between the observed and computed spectra and can also be used as template for other stars of the same spectral type. For instance, HD 175640 is an excellent example of a star very overabundant in Mn ([+2.4]), while HR 6000 is an example of a star overabundant in Fe ([+0.7]).

P03: Electron-impact broadening of ionized chromium lines for Ap star atmospheres analysis

M.S. Dimitrijevic [1], T. Ryabchikova [2,3], Z. Simic [1], L.C. Popovic [1], & M. Dacic [1]

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[2] *Institute of Astronomy, Russian Academy of Science, Moscow, Russia*

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The influence of Stark broadening on the shapes of Cr II spectral lines observed in stellar atmospheres has been considered. The corresponding Stark broadening parameters for seven multiplets belonging to 4s-4p transitions, were calculated by the semiclassical perturbation approach and applied to the analysis of Cr II line profiles observed in the spectrum of Cr-rich star HD 133792. For stellar spectra synthesis, the improved version of the code SYNTH for synthetic spectrum calculations was used. We found that Stark broadening mechanism is very important and should be taken into account, especially in the study of Cr abundance stratification.

P04: On the Stark broadening of Te I spectral lines for Cp star plasma analysis

M.S. Dimitrijevic [1], Z. Simic [1], A. Kovacevic [2], M. Dacic [1], & S. Sahal-Brechot [3]

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[3] *LERMA, Observatoire de Paris-Meudon, Meudon, France*

With the development of astronomical observations from space, even such trace element lines like the tellurium one become to be observed in stellar spectra. Since the significance of the corresponding atomic data, including Stark broadening parameters increases with the development of space-born spectroscopy, we investigate here theoretically the influence of collisions with charged particles on spectral lines of neutral tellurium. By using the semiclassical perturbation method, Stark widths and shifts of three Te I spectral lines, of interest for modellisation, investigation and diagnostic of stellar plasma have been obtained. Results were applied for the investigation of the influence of Stark broadening mechanism on the CP star spectra.

P05: Abundance determinations of A/F and Am/Fm stars in the Pleiades and Coma Berenices open clusters

M. Gebran [1]

[1] *GRAAL, Université de Montpellier II, Montpellier, France*

Abundances of 18 chemical elements have been derived for 27 A ("normal" and chemically peculiar) and 16 F stars members of Pleiades (age about 100 Myr) and Coma Berenices (age about 450 Myr) open clusters. Assuming LTE, the abundances were determined by minimising the chi-square of grids of synthetic spectra to observed high resolution (R = 42000, 60000, 75000) high S/N echelle spectra obtained at the Observatoire de Haute-Provence (OHP). A semi-automated procedure was used to derive the abundances of C, O, Na, Mg, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Sr, Y, Zr and Ba, the projected rotational velocity vesini and the microturbulent velocity for each star analysed. For all the elements, we found no trend between [X/H] and fundamental parameters (Teff , vesini). For both clusters and for C, Sc, Ti, Cr, Mn, Sr, Y, Zr and Ba, A stars exhibit larger star to star variations in [X/H] than F stars do. [C/Fe] and [O/Fe] are anti-correlated with [Fe/H] for A stars. The scenario of gas to dust separation is mentioned by analysing the trend of [C/Si] versus [Si/H] for A stars. These abundance determinations are confronted to recent evolutionary models of A and F stars including transport processes.

P06: The magnetic field generated by sources inside and outside the star

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The ubiquitously in universe present magnetic fields reveal themselves only by physical interaction with the interspersed material, especially by the Faraday and the Zeeman effects. The magneto-sensitive atmosphere of a star is an ideal detector of the magnetic field penetrating the atmosphere layer – indifferently from which side. Hitherto the origin of the magnetic field of a star was sought for mainly in its interior, neglecting the possibility of externally caused influence. It should not be denied, however, that most magnetic stars possess their own magnetic moment. The detection of a field depends, of course, on

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ABSTRACT BOOK

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The influence of Stark broadening on the shapes of Cr II spectral lines observed in stellar atmospheres has been considered. The corresponding Stark broadening parameters for seven multiplets belonging to 4s-4p transitions, were calculated by the semiclassical perturbation approach and applied to the analysis of Cr II line profiles observed in the spectrum of Cr-rich star HD 133792. For stellar spectra synthesis, the improved version of the code SYNTH for synthetic spectrum calculations was used. We found that Stark broadening mechanism is very important and should be taken into account, especially in the study of Cr abundance stratification.

P04: On the Stark broadening of Te I spectral lines for Cp star plasma analysis

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With the development of astronomical observations from space, even such trace element lines like the tellurium one become to be observed in stellar spectra. Since the significance of the corresponding atomic data, including Stark broadening parameters increases with the development of space-born spectroscopy, we investigate here theoretically the influence of collisions with charged particles on spectral lines of neutral tellurium. By using the semiclassical perturbation method, Stark widths and shifts of three Te I spectral lines, of interest for modellisation, investigation and diagnostic of stellar plasma have been obtained. Results were applied for the investigation of the influence of Stark broadening mechanism on the CP star spectra.

P05: Abundance determinations of A/F and Am/Fm stars in the Pleiades and Coma Berenices open clusters

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Abundances of 18 chemical elements have been derived for 27 A ("normal" and chemically peculiar) and 16 F stars members of Pleiades (age about 100 Myr) and Coma Berenices (age about 450 Myr) open clusters. Assuming LTE, the abundances were determined by minimising the chi-square of grids of synthetic spectra to observed high resolution (R = 42000, 60000, 75000) high S/N echelle spectra obtained at the Observatoire de Haute-Provence (OHP). A semi-automated procedure was used to derive the abundances of C, O, Na, Mg, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Sr, Y, Zr and Ba, the projected rotational velocity vesini and the microturbulent velocity for each star analysed. For all the elements, we found no trend between [X/H] and fundamental parameters (Teff , vesini). For both clusters and for C, Sc, Ti, Cr, Mn, Sr, Y, Zr and Ba, A stars exhibit larger star to star variations in [X/H] than F stars do. [C/Fe] and [O/Fe] are anti-correlated with [Fe/H] for A stars. The scenario of gas to dust separation is mentioned by analysing the trend of [C/Si] versus [Si/H] for A stars. These abundance determinations are confronted to recent evolutionary models of A and F stars including transport processes.

P06: The magnetic field generated by sources inside and outside the star

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The ubiquitously in universe present magnetic fields reveal themselves only by physical interaction with the interspersed material, especially by the Faraday and the Zeeman effects. The magneto-sensitive atmosphere of a star is an ideal detector of the magnetic field penetrating the atmosphere layer – indifferently from which side. Hitherto the origin of the magnetic field of a star was sought for mainly in its interior, neglecting the possibility of externally caused influence. It should not be denied, however, that most magnetic stars possess their own magnetic moment. The detection of a field depends, of course, on

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ABSTRACT BOOK

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P28: Magnetic fields in X-ray emitting A-type stars

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A common explanation for the observed X-ray emission of A-type stars is the presence of a hidden late-type companion. While this hypothesis can be shown to be correct in some cases, there is also evidence suggesting that low-mass companions cannot be the correct cause for the observed X-ray activity in all cases. Babel and Montmerle (1997) presented a theoretical framework to explain the X-ray emission for magnetic Ap/Bp stars, focussing on the A0p star IQ Aur. We test if this theoretical model is capable to explain the observed X-ray emissions. We present the observations of 13 A-type stars that have been associated with X-ray emission detected by ROSAT. To determine the mean longitudinal magnetic field strength we measured the circular polarization in the wings of the Balmer lines using FORS 1. Although the emission of those objects with magnetic fields fits the prediction of the Babel and Montmerle model, not all X-ray detections are related to the presence of a magnetic field. Additionally, the measured strengths of magnetic fields do not correlate with the X-ray luminosity and thus the magnetically confined wind shock model cannot explain the X-ray emission from all investigated stars.

P29: Model atmospheres of magnetic CP stars: HD137509

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We present the results of modeling the atmosphere of one of the extreme magnetic CP star HD137509, which has the mean surface magnetic field module of about 29 kG. Such a strong field, as well as clearly observed abundance peculiarities, make this star one of the most preferable target for testing our assumptions about the atmospheric structure of magnetic stars. The calculations presented are based on resent version of the LLmodels stellar model atmosphere code which accounts for full treatment of Zeeman splitting of spectral lines and polarized radiative transfer.

P30: On the Stark broadening of Mn II lines for Ap star conditions

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In CP star atmospheres exist conditions where Stark widths are comparable and even larger than the thermal Doppler widths, so that the corresponding line broadening parameters are of importance for the CP star plasma investigations. Ionized manganeze lines are present in CP star spectra and the relevant line broadening data may be significant for their analysis and synthesis as well as for the modelling and consideration of subphotospheric layers. Recently, a disagreement of up to 5.7 times is found between experimental and calculated Stark widths and shifts of Mn II lines. In order to investigate the possible reasons, we performed more sophysticated calculations for six Mn II lines, by using the semiclassical perturbation theory. Calculations were also performed for ionized helium impact broadening in order to check if this contribution may improve the agreement between experiment and theory. Moreover, we made a detailed analysis of the influence of hfs splitting on the considered experimental results. Also, the obtained results have been applied to compare Doppler and Stark broadening contributions in CP star atmospheres.

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ON STARK BROADENING DATA FOR STELLAR PLASMA RESEARCH

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Abstract. Here is presented a review of semiclassical calculations of Stark broadening parameters and the comparison of different semiclassical procedures is discussed, as well as the agreement with critically selected experimental data and more sophysticated, close coupling calculations. Approximate methods for the calculation of Stark broadening parameters, usefull especially in such astrophysical problems where large scale calculations and analyses must be performed and where only a good average accuracy is expected, have been discussed as well.

Key words: atomic data

1. Astrophysical aspects of the Stark broadening research

It is difficult to state in general terms which are the relevant transitions since the atmospheric composition of a star is not known a priori, and many interesting groups of stars exist with very peculiar abundances as compared to the Sun. Consequently, stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters.

The interest for a very extensive list of line broadening data is additionally stimulated by the developement of space astronomy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, stimulating the spectral–line–shape research.

Here is presented a review of semiclassical calculations of Stark broadening parameters. Moreover the comparison of different semiclassical procedures is discussed, as well as the agreement with critically selected experimental data and more sophysticated, close coupling calculations. Approximate methods for the calculation of Stark broadening parameters, have been discussed as well.

Broadening due to interaction between emitter and charged particles (Stark broadening) is dominant in several cases of astrophysical interest. For $T_{\rm eff} > 10^4$K, hydrogen, the main constituent of a stellar atmosphera is mainly ionized, and among collisional broadening mechanisms for spectral lines, the dominant is the Stark effect. This is the case for white dwarfs and hot stars of O, B and A0

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type. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level (Dimitrijević & Sahal-Bréchot, 1984a,b; 1985a) and consequently, Stark broadening contribution may become significant even in the Solar spectrum (Vince & Dimitrijević, 1985; Vince et al. 1985a,b).

For example, high member Balmer series lines may be used as a powerful diagnostic tool in studying stellar atmospheres. In Feldman & Doschek (1977), profiles of Balmer series members with the principal quantum number n between 16 and 32 (strongly influenced by Stark effect) have been used to determine the electron density and the temperature over an active Solar region.

Reliable Stark broadening data are also needed for the determination of chemical abundances of elements from equivalent widths of absorption lines and for the estimation of the radiative transfer through the stellar plasmas, especially in subphotospheric layers as well as for opacity calculations. In such a case data for especially large numbers of lines are needed. An illustrative example might be the article on the calculation of opacities for classical cepheid models (Iglesias et al. 1990), where 11,996.532 spectral lines have been taken into account(45 lines of H, 45 of He, 638 of C, 54 of N, 2390 of O, 16 030 of Ne, 50170 of Na, 105 700 of Mg, 145 200 of Al, 133 700 of Si, 12 560 of Ar and 11 530 000 of Fe), and where Stark broadening is important.

2. Semiclassical method

In spite of the fact that the most sophisticated theoretical method for the calculation of a Stark broadened line profile is the quantum mechanical strong coupling approach, due to its complexity and numerical difficulties, only a small number of such calculations exist. For example, the strong coupling method is used for Li I (2s–2p) (Dimitrijević et al., 1981), Ca II (4s–4p and 3d–4p) , (Barnes, 1971; Barnes & Peach, 1970) Mg II (3s–3p) (Barnes, 1971; Bely & Griem, 1970) and Be II (2s–2p) (Sanchez et al., 1973) lines. Recently, Seaton performed close coupling calculations for 42 transitions in Li–like ions Be II, B III, C IV, O VI, Ne VIII (Seaton, 1988) and for transitions $2s^{21}S$– $2s2p^1P^o$, $2s2p^3P^o$ – $2p^{23}P$ and $2s2p^1P^o$ – $2p^{21}D$ and ^1S in C III, O V and Ne VII (Seaton, 1987).

In a lot of cases such as e.g. complex spectra, heavy elements or transitions between more excited energy levels, the more sophysticated quantum mechanical approach is very difficult or even practically impossible to use and, in such cases, the semiclassical approach remains the most efficient method for Stark broadening calculations.

The existing large scale calculations of Stark broadening parameters were performed by using three different computer codes, developed by (i) Jones, Benett & Griem (Jones et al., 1971; Benett & Griem, 1971; Griem, 1974), (ii) Sahal–Bréchot (1969a,b) and (iii) Bassalo, Cattani & Walder (1982).

In the computer code of Bassalo, Cattani and Walder, so called convergent theory, originally developed by Vainshtein & Sobel'man (1959) has been used. Using the similarity between the Dyson series for S matrix perturbational development and Taylor series for exponential function, this method avoids the divergence in the integration over impact parameter (ρ) when ρ tends to 0 (Vainshtein & Sobel'man, 1959).

Comprehensive calculations of Stark broadening parameters of non–hydrogenic neutral and singly ionized atom lines (helium through calcium and cesium) using the computer code of Jones, Benett & Griem, were published in 1971 and later in 1974 (Jones et al., 1971; Benett & Griem, 1971; Griem, 1974). Using the same code (Griem, 1974) and the version adapted by Dimitrijević for the case of multiply charged ions, data for Br I, Ge I, Hg I, Pb I, Rb I, Cd I, Zn I (Dimitrijević & Konjević, 1983), O II (Dimitrijević, 1982a), O III (Dimitrijević, 1980a), C III (Dimitrijević, 1980b), C IV (Dimitrijević, 1980b; 1988a), N II, N III, N IV (Dimitrijević & Konjević, 1981a), S III, S IV, Cl III (Dimitrijević & Konjević, 1982) and Ti II, Mn II (Dimitrijević, 1982b) have been published. Semiclassical calculations based on the method developed by Sahal–Bréchot (1969a,b) exist for lighter elements such as C, N, Mg, Si (without the contribution of resonances [see e.g. Sahal-Bréchot & Segre (1971) and References therein]. Data for alkali like ions Be II; Mg II, Ca II, Sr II and Ba II may be found in Fleurier et al. (1977), while in Lesage et al. (1983) the semiclassical and experimental data for the low–excitation Si II lines have been compared. Recently, using the same computer code, extensive calculations for 79 neutral helium multiplets (Dimitrijević & Sahal-Bréchot, 1984a,b), 62 sodium (Dimitrijević & Sahal-Bréchot, 1985; 1990b,c), 51 potassium (Dimitrijević & Sahal-Bréchot, 1987; 1990d), 61 lithium (Dimitrijević & Sahal-Bréchot, 1991a,b), 25 aluminium (Dimitrijević & Sahal-Bréchot, 1992a; 1993a), 24 rubidium (Dimitrijević & Sahal-Bréchot, 1992b; 1994), 3 paladium (Dimitrijević 1993b), 19 berrylium (Dimitrijević & Sahal-Bréchot, 1992c), 28 Ca II (Dimitrijević & Sahal-Bréchot, 1992d; 1993c), 30 Be II (Dimitrijević & Sahal-Bréchot, 1992e,f), 23 Al III (Dimitrijević & Sahal-Bréchot, 1993d,e), 10 Sc III, 10 Ti IV (Dimitrijević & Sahal-Bréchot, 1992g), 39 Si IV (Dimitrijević et al., 1991a,b), 90 C IV ((Dimitrijević et al., 1991c,d; Dimitrijević & Sahal-Bréchot, 1992h), 30 N V (Dimitrijević & Sahal-Bréchot, 1992i), 30 O VI (Dimitrijević & Sahal-Bréchot, 1992j), 21 S VI (Dimitrijević & Sahal-Bréchot, 1993f), and 10 F VII (Dimitrijević & Sahal-Bréchot, 1993g) multiplets become available and data for Ne VIII, Na IX, Al XI, Si XII and Mg I are in preparation. Data for particular lines of F I (Vujnović et al. 1983), Ar II (Dimitrijević & Truong-Bach,1986), Ga II, Ga III (Dimitrijević & Artru, 1986), Si II (Lanz et al., 1988), Cl I, Br I, I I (Djurović et al., 1990), Cu I (Dimitrijević & Vujnović, 1990) and Hg II (Dimitrijević, 1992) also exist. Extensive calculations by Bassalo, Cattani and Walder obtained using the convergent semiclassical method exist for He I lines.

All three methods have been compared with critically selected experimental data for 13 He I multiplets (Dimitrijević & Sahal-Bréchot, 1985b). The agreement between experimental and all three semiclassical calculations is within the limits of ±20%, what is the predicted accuracy of the semiclassical method (Griem, 1974).

Generally, the width data are more reliable than the shift data, since shift calculations are more sensitive to the small variations of various parameters. The reason is because shifts are smaller than widths and produced in average by more distant collisions.

Finally, if the theoretical data do not exist, the reviews of critically selected experimental data (Konjević & Roberts, 1976; Konjević & Wiese, 1976; Konjević et al, 1984a,b; Konjević & Wiese, 1990) may be also very helpful.

3. Approximate method

Whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important, simple approximative formulae with good average accuracy may be very useful. Moreover, in the case of more complex atoms or multiply charged ions the lack of the accurate atomic data needed for more sophysticated calculations, makes that the reliability of the semiclassical results decreases. In such cases approximate methods might be very interesting. We might devide all approximate methods for calculations of Stark broadening parameters in the three groups. In the first one are methods where the most complicated part of the calculation, the cross sections for the corresponding dipole transitions are calculated using averaged experimental [e.g. (Griem, 1968; Dimitrijević & Konjević, 1980, 1981b,c; 1987; Dimitrijević & Kršljanin, 1986; Dimitrijević, 1988b; Hey & Bryan, 1977) or theoretical (Seaton, 1987) data. In the second group, one might put methods where the most complicated part is obtained by the symplifications in the more sophysticated theory (e.g. Griem, 1974) or e.g. by interpolation between theoretically simpler limits (e.g. Dimitrijević & Konjević, 1986). In the third group are the possibilities for the interpolation of new data by using regularities and systematic trends (e.g. Wiese & Konjević, 1982; Dimitrijević & Peach, 1990; Dimitrijević, 1985; Dimitrijević & Popović, 1989; Purić et al, 1980; 1991; Lakićević & Purić, 1983; Vitel et al., 1988; Djeniže et al., 1990).

For the astrophysical purposes, of particular interest might be the symplified semiempirical formula (Dimitrijević & Konjević, 1987) for Stark widths of isolated, singly, and multiply charged ion lines applicable in the cases when the nearest atomic energy level (j'=i'or f')where a dipolly allowed transition can occur from or to initial (i) or final (f) energy level of the considered line, is so far, that the condition $x_{\mathrm{jj}'} = E/|E_{\mathrm{j}'} - E_{\mathrm{j}}| \leq 2$ is satisfied. In such a cases full width at half maximum is given by the expression (Dimitrijević & Konjević, 1987):

$$W(\text{Å}) = 2.2151\times10^{-8}\frac{\lambda^2(\text{cm})\text{N}(\text{cm}^{-3})}{\text{T}^{1/2}(\text{K})}(0.9-\frac{1.1}{\text{Z}})\sum_{\text{j=i,f}}(\frac{3\text{n}_\text{j}^*}{2\text{Z}})^2(\text{n}_\text{j}^{*2}-\ell_\text{j}^2-\ell-1) \quad (1)$$

Here, N and T are the electron density and temperature respectively,$E = 3kT/2$ is the energy of perturbing electron, $Z - 1$ is the ionic charge and n the effective principal quantum number. This expression is of interest for abundance calculations, as well as for stellar atmospherae research, since the validity conditions are often satysfied for stellar plasma conditions.

Similarly, in the case of the shift

$$d(\text{Å}) = 1.1076 \times 10^{-8}\tfrac{\lambda^2(\text{cm})\text{N}(\text{cm}^{-3})}{\text{T}^{1/2}(\text{K})}(0.9 - \tfrac{1.1}{\text{Z}})\tfrac{9}{4\text{Z}^2}\times\}$$

$$\times\sum_{\text{j=i,f}}\frac{n_\text{j}^*\varepsilon_\text{j}^2}{2\ell_\text{j}+1}\{(\ell_\text{j}+1)[n_\text{j}^{*2}-(\ell_\text{j}+1)^2]-\ell_\text{j}(n_\text{j}^{*2}-\ell_\text{j}^2)\}, \quad (2)$$

where $\varepsilon = +1$ if j= i and -1 if j= f.

If all levels $\ell_{\text{i,f}} \pm 1$ exist, an additional summation may be performed in equation (2) to obtain

$$d(\text{Å}) = 1.1076\times10^{-8}\frac{\lambda^2(\text{cm})\text{N}(\text{cm}^{-3})}{\text{T}^{1/2}(\text{K})}(0.9-\frac{1.1}{\text{Z}})\frac{9}{4\text{Z}^2}\sum_{\text{j=i,f}}\frac{\text{n}_\text{j}^*\varepsilon_\text{j}^2}{2\ell_\text{j}+1}(\text{n}_\text{j}^{*2}-3\ell_\text{j}^2-3\ell_\text{j}-1). \quad (3)$$

When the simplified semiempirical formula is not applicable, the good possibilities gives the modified semiempirical method (Dimitrijević & Konjević, 1980; 1981b; 1987; Dimitrijević & Kršljanin, 1986; Dimitrijević, 1988b). In order to test the modified semiempirical approach, selected experimental data for 36 multiplets (7 different ion species) of triply–charged ions were compared with theoretical linewidths. The averaged values of the ratios of measured to calculated widths are as follows (Dimitrijević & Konjević, 1980): for doubly charged ions 1.06 ± 0.32 and for triply–charged ions 0.91 ± 0.42. The modified semiempirical approach has been tested several times on numerous examples (Dimitrijević, 1990). The width data for the most intensive lines for the following atom and ion species are availlable: Be III, B III, B IV, C III, C IV, N III, N IV, O III, O IV, F III, Ne III, Ne IV, Na III, Mg IV, Al III, Si III, Si IV, P III, P IV, S III, S IV, Cl III, Cl IV, Ar III, Ar IV (Dimitrijević & Konjević, 1981b; Dimitrijević 1988b); C V, N VI, O V, F V, F VI, Ne V, Ne VI, Al V, Si V, Si VI, P VI, and Cl VI (Dimitrijević, 1993b). Moreover, the width data are published for the particular lines of Ti II, Mn II (Dimitrijević, 1990), Fe II (Dimitrijević, 1988c), Cu IV (Dimitrijević et al., 1989), Pt II (Dimitrijević, 1993c), Bi II (Dimitrijević, & Popović, 1994), Zn II, Cd II (Popović et al., 1994) and the shift data for Ar II lines (Kršljanin & Dimitrijević, 1989a,b).

4. Regularities and systematic trends

When reliable data do not exist, the knowledge on regularities and systematic trends of line broadening parameters can be used for quick acquisition of new data especially when high accuracy of each particular value is not needed.

Regularities and systemic trends for the widths of isolated non–hydrogenic spectral lines in plasmas have been studied recently in a number of papers (see for example Dimitrijević, 1982a; Wiese & Konjević, 1982; Dimitrijević & Peach, 1990; Dimitrijević, 1985; Dimitrijević & Popović, 1989; Purić et al, 1980; 1991; Lakićević & Purić, 1983; Vitel et al., 1988; Djeniže et al., 1990; Konjević & Dimitrijević, 1981). The aim of such studies is to find out if regularities and systematic trends can be used to predict line widths and to critically evaluate experimental data. With the suitable use of the knowledge of regularities and systematic trends, we might use the existing experimental and theoretical values for the interpolation of new data needed in stellar spectroscopy. One must take into account however, that the validity of systematic trends and line broadening data is limited to the plasma conditions for which they are derived and extrapolations are of low accuracy.

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ON STARK BROADENING OF HEAVY ION LINES IN SPECTRA OF CP STARS: Sb II LINES

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Abstract. We present here Stark broadening data for three Sb II multiplets as a function of temperature. Stark broadening data have been calculated within the modified semi-empirical approach for electron density of 10^{23} m^{-3}. The Stark width data for Sb II multiplets are compared with corresponding thermal Doppler widths for typical plasma condition within CP stars (e.g. A_m) layers where Sb II lines are formed. Our results show that Stark width for higher multiplets may be even more important than the thermal Doppler one.

Key words: stars: chemically peculiar – atomic data

1. Introduction

Strong absorption heavy ion lines have been observed in spectra of CP stars, as e.g. Sb II spectral line (λ = 143.65 nm) in spectra of HR 7775 and ι CrB (Hg-Mn) stars (Jacobs & Dworetsky, 1982). Since the electron density in layers where the Sb II lines are formed is $10^{20} - 10^{21}$ m^{-3} it is of interest to provide the corresponding Stark broadening data wich might be of significance for the analysis of stellar spectra.

In this paper we present our calculations of the corresponding Stark widths and shifts with the modified semiempirical approach (Dimitrijević & Konjević, 1980).

2. Results and discussion

For the Stark broadening data calculation the modified semiempirical approach (Dimitrijević & Konjević, 1980, Dimitrijević & Kršljanin, 1986) has been used. The oscillator strengths needed for calculation have been taken from Wiese & Martin (1980) and Gruzdev (1968). The needed atomic energy levels have been taken from Moore (1971). The deparature from *LS* coupling has been taken into account (see Dimitrijević & Popović, 1993) as well.

In Table 1. we have compared Stark (w_{St}) and thermal Doppler (w_{Dopp}) full widths for three multiplets for typical conditions in A type star layers where Sb II lines are formed. As one can see from Table 1. Stark widths in the case

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Table 1. Comparison of Stark and thermal Doppler full widths for Sb II multiplets for $T = 10\,000$ K and the electron density of 10^{21} m^{-3}.

Transition	$w_{\rm St}$ (nm)	$w_{\rm Dopp}$ (nm)
$6s^3P_1^0 - 6p^3D_2$ $\lambda = 600.5$ nm	.111E-02	.234E-02
$6s^3P_2^0 - 6p^3P_1$ $\lambda = 927.8$ nm	.448E-02	.361E-02
$6s^3P_2^0 - 6p^3S_1$ $\lambda = 564.1$ nm	.202E-02	.220E-02

of considered multiplets may be even larger than widths due to the thermal Doppler effect. This may be expected in the case of transitions involving higher principal quantum number. In such cases due to the weaker influence of the core on the optical electron, which is more sensitive to the weak electron field, Stark broadening may be important even in the atmospheres of cooler stars as e.g. the Sun (Vince *et al.*, 1985).

Table 2. Stark full widths (w) and shifts (d) of Sb II spectral lines as a function of temperature. The electron density is 10^{23} m^{-3}.

Transition	T(K)	w (nm)	d (nm)
$6s^3P_1^0 - 6p^3D_2$ $\lambda = 600.5$ nm	5000.	.160	-.539E-01
	10000.	.111	-.399E-01
	20000.	.809E-01	-.315E-01
	30000.	.717E-01	-.291E-01
	40000.	.685E-01	-.280E-01
	50000.	.676E-01	-.263E-01
$6s^3P_2^0 - 6p^3P_1$ $\lambda = 927.8$ nm	5000.	.637	-.339
	10000.	.448	-.256
	20000.	.334	-.211
	30000.	.300	-.215
	40000.	.286	-.221
	50000.	.281	-.229
$6s^3P_2^0 - 6p^3S_1$ $\lambda = 564.1$ nm	5000.	.271	-.929E-01
	10000.	.202	-.631E-01
	20000.	.162	-.336E-01
	30000.	.160	-.224E-01
	40000.	.157	-.214E-01
	50000.	.153	-.219E-01

In Table 2. we present Stark full width (w) and shift (d) for three multiplets, calculated by using the modified semiempiricial approach (Dimitrijević & Kon-

Table 3. Comparison of experimental (Purić *et al.*, 1985) and theoretical results. The electron density is 10^{23} m^{-3}.

Transition	λ (nm)	T (1000 K)	$w_{\text{exp}}/w_{\text{MSE}}$	$d_{\text{exp}}/d_{\text{MSE}}$
$6s^3P_1^0 - 5p^3D_2$	603.5	16	2.0	1.3
		20	1.8	1.0

jević, 1980, Dimitrijević & Kršljanin, 1986) for electron density of 10^{23} m^{-3} and temperatures from 5000 to 50000 K.

In Table 3. our results have been compared with available experimental data (Purić *et al.*, 1985). We can see that shifts are in better agreement with our calculations than the widths.

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Stark broadening parameter regularities and interpolation and critical evaluation of data for CP star atmospheres research: Stark line shifts

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Abstract. In order to find out if regularities and systematic trends found to be apparent among experimental Stark line shifts allow the accurate interpolation of new data and critical evaluation of experimental results, the exceptions to the established regularities are analysed on the basis of critical reviews of experimental data, and reasons for such exceptions are discussed.

We found that such exceptions are mostly due to the situations when: (i) the energy gap between atomic energy levels within a supermultiplet is equal or comparable to the energy gap to the nearest perturbing levels; (ii) the most important perturbing level is embedded between the energy levels of the supermultiplet; (iii) the forbidden transitions have influence on Stark line shifts.

Key words: line profile – atomic data

1. Introduction

Wiese and Konjević (1982) established that for experimental Stark widths of non-hydrogenic lines, there are similarities (see as well references in Wiese & Konjević 1982 and Dimitrijević 1982) of line widths within a multiplet, a supermultiplet and a transition array, as well as for analogous transitions of homologous atoms and ions. They found as well a systematic behaviour of Stark line widths along spectral series. The exceptions to these similarities and systematic trends have been analyzed by Dimitrijević (1982), who found that the reasons for such exceptions may be divided in two categories: (i) irregular atomic energy level structure and (ii) inadequacy of the model used for the emitter structure. He emphasized as well, that the simple analysis of Grotrian diagrams for corresponding radiator energy levels, may be useful for prediction of mutual relations among Stark widths within multiplets, supermultiplets and transition arrays. Extending their work of 1982 on Stark widths, Wiese & Konjević (1992) carried out the same kind of research on experimental Stark line shifts, and showed numerous examples where the same regularities and systematic trends hold. Similarly as in Dimitrijević (1982) for widths, we want to analyze here the exceptions to the established regularities and systematic trends for Stark line shifts.

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2. Results and discussion

The exceptions to the established regularities have been analysed on the basis of critical reviews of experimental data (Konjević & Roberts 1976; Konjević & Wiese 1976; Konjević et al. 1984ab; Konjević & Wiese 1990). The complete analysis will be published elsewhere. We found that such exceptions are mostly due to the situations when: (i) the energy gap between atomic energy levels within a supermultiplet is equal or comparable to the energy gap to the nearest perturbing levels; (ii) the most important perturbing level is embedded between the energy levels of the supermultiplet; (iii) the forbidden transitions have influence on Stark line shifts.

Table 1. Experimental Stark shifts d[Å] from Djurović and Konjević (1988). Plasma conditions are: Temperature = 9700 - 9800 K; electron density is 10^{17}cm^{-3}.

element	transition (mult.No)	J_L	J_H	λ[Å]	d[Å]
F I	$3s^4P-3p^4P^0$	5/2	3/2	7331.96	0.03
		5/2	5/2	7398.69	0.03
	$3s^4P-3p^4D^0$	1/2	3/2	6909.82	0.16
		3/2	5/2	6902.48	0.16
		5/2	7/2	6856.03	0.16
	$3s^4P-3p^4S^0$	3/2	3/2	6348.51	0.26
		5/2	3/2	6239.65	0.25

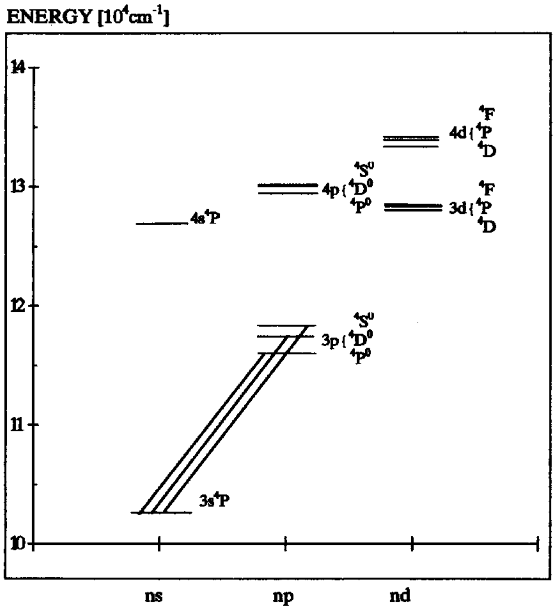

Figure 1. Partial Grotrian diagram for F I 3s, 4s, 3p, 4p, 3d, 4d

The example of Stark line shifts from F I 3s - 3p (quartets) supermultiplet, illustrates the case when the energy gap between upper atomic energy levels for particular members of a supermultiplet is not negligible in comparison to the energy gap to the most important perturbing levels. For the $3p^4S^o$ energy level for instance, the influence of the upper perturbing levels 4s and 3d, is larger in comparison with this influence for the $3p^4P^o$ energy level, and the contribution of the 3s energy level is smaller. The effect of such an energy structure is larger on the shift than on the width, since all partial contributions to the width are positive while the contribution of the level 3s as a perturbing level of 4p to the shift is negative. Consequently, the shift of lines within the $3s^4P$ - $3p^4S^o$ multiplet is larger than the shifts within the $3s^4P$ - $3p^4P^o$ multiplet.

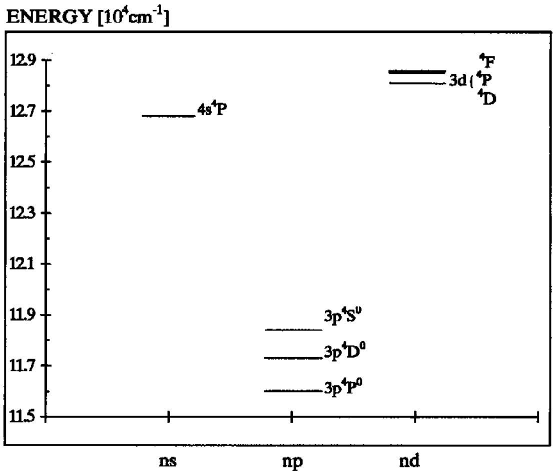

Figure 2. Partial Grotrian diagram for F I 4s, 3p, 3d

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A program for electron-impact broadening parameter calculations of ionized rare-earth element lines

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Abstract. In order to provide atomic data needed for astrophysical investigations, a set of electron-impact broadening parameters for ionized rare-earth element lines should be calculated. We are going to calculate the electron-impact broadening parameters for more than 50 transitions of ionized rare-earth elements. Taking into account that the spectra of these elements are very complex, for calculation we can use the modified semiempirical approach – MSE or simplified MSE. Also, we can estimate these parameters on the basis of regularities and systematic trends.

Key words: rare-earths – line profile – atomic data

1. Motivation

The spectral lines of rare-earth elements are present in Solar as well as in stellar spectra (see e.g. Grevesse & Blanquet 1969, Molnar 1972, Adelman 1987, Mathys & Cowley 1992, Sadakane 1993, Bidelman et al. 1995, Cowley et al. 1996, etc.). Principally, these lines originate in layers of stellar atmospheres with higher electron density (photosphere or subphotosphere). Consequently, electron-impact broadening mechanism can be important, especially for hot (A and B) stars as well as for white dwarfs. So, it is important to have a set of electron-impact broadening data for the lines of ionized rare-earth elements. For some transitions of La II and La III we have calculated Stark widths (Popović & Dimitrijević 1997) by using the modified semiempirical approach (Dimitrijević & Konjević 1980, Popović & Dimitrijević 1996a,b). Here we present our plans and specify the number of lines for which we may calculate electron-impact broadening parameters with a satisfying accuracy and discuss the difficulties which may appear in the calculation.

2. Methods of calculation

Due to the lack of known energy levels as well as of reliable transition probabilities for rare-earth elements, the approximate methods are adequate for Stark broadening calculations. Consequently the modified semiempirical approach will be applied. This method was developed by Dimitrijević & Konjević(1980). For

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the case of ions with complex spectra the improvement was done by Popović & Dimitrijević (1996a,b). Also, as regards lines for which it is not possible to apply this method, we will use the simplified modified semiempirical formula (SMSE) given by Dimitrijević & Konjević (1987). For the lines which are very important for astrophysical purposes and for which, due to the lack of atomic data, it is not possible to use even the SMSE method, we will estimate Stark broadening parameters on the basis of regularities and systematic trends (RST, Dimitrijević & Popović 1989).

Table 1. List of the ions for which we are going to calculate the electron-impact broadening parameters. The number of transitions given in the table could be calculated using the modified-semiempirical (MSE) and simplified modified-semiempirical (SMSE) methods, the x indicates that the data can be provided for several other transitions by using regularities and systematic trends (RST) for astrophysically very important lines. Key to the columns: I, IV – Ion, II, V – Number of transition for which we can calculate the Stark broadening parameters, III, VI – Method which we are going to use.

I	II	III	IV	V	VI
La II	3+x	SMSE+RST	La III	6+x	MSE+RST
La IV	x	RST	Ce II	x	RST
Ce III	5+x	SMSE+RST	Ce IV	4+x	MSE+RST
Pr II,III	x	RST	Nd II	5+x	SMSE+RST
Nd III	x	RST	Sm II	x	RST
Eu III	2+x	SMSE+RST	Gd II	2+x	SMSE+RST
Tb III	3+x	SMSE+RST	Ho II	2+x	SMSE+RST
Ho III	x	RST	Er II	1+x	SMSE+RST
Er III	x	RST	Tm II,III	x	RST
Yb II	5+x	MSE(SMSE)+RST	Yb III	3+x	MSE+RST
Yb IV	x	RST	Lu II	2+x	SMSE+RST
Lu III	5+x	MSE+RST	Lu IV	3+x	MSE+RST

Moreover, due to the very complex spectra of ionized rare-earth elements we have to improve the existing software developed by us (Popović 1994). It means that calculations within intercoupling approximation have to be performed. For example in the spectra of Ce III, the $4f6p$ levels are well described by jj coupling approximation, while $4f6d$ levels, which are perturbed by $4f6p$ ones, are well described by $j\ell$ coupling approximation. Such interaction between these two levels should be taken into account. Also, a numerical experiment about the influence of this effect on calculated parameters should be done.

3. The list of ions

In Table 1 we present the ions and number of lines for which we are going to calculate the electron-impact broadening parameters. As one can see from Table 1, there is a very limited number of transitions for which this is possible (only 51 transitions). The list has been made taking into account atomic data given by Martin et al. (1978), so, this list may be extended after a detailed search through literature and after including the new experimental results.

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D.I.A.M.

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106- INFLUENCE OF ION-ATOM COLLISIONS ON THE ABSORPTION OF RADIATION IN HELIUM PLASMA.

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The significance of the combined study of the processess of the photodissociation

$$H_2^+ + \hbar\omega \rightarrow H + H^+ \tag{1a}$$

and the absorption of electromagnetic radiation by collisional ion-atom complexes

$$H + H^+ + \hbar\omega \rightarrow \begin{cases} H + H^+ \\ H^+ + H \end{cases} \tag{1b}$$

has been demonstrated recently by Mihajlov and Dimitrijević (1986), for the conditions characteristic for stellar plasma ($T \lesssim 10000$ K). An interesting case where the developped method can be applied directly, is the process

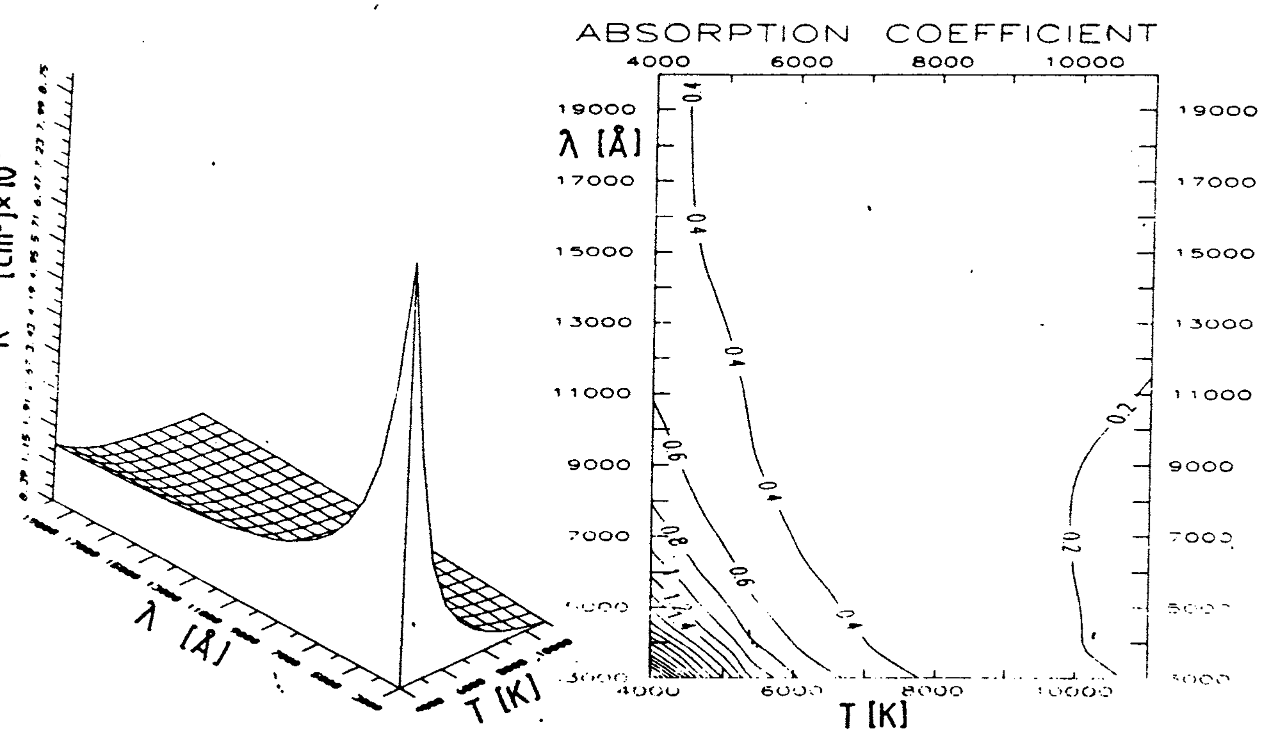
$$He_2^+ + \hbar\omega \rightarrow He + He^+ \tag{2a}$$

$$He + He^+ + \hbar\omega \rightarrow \begin{cases} He + He^+ \\ He^+ + He \end{cases} \tag{2b}$$

where He is in the ground state.

Recent calculations by Gaur et al (1988) indicate that in helium rich non-DA white dwarfs, He_2^+ is the most abundant molecule in the atmospheres. The gas pressures typical for helium-rich white dwarf atmospheres are 10^7 - 10^{10} dyn cm^{-2} (Koester, 1980). It is of interest therefore to investigate the importance of the usually neglected (2b) process (Mihalas, 1978) and provide the corresponding absorption coefficients. The total absorption coefficient for processes (2a) and (2b) together, normalized to the density $N(A) = N(A^+) = 1$, is calculated using the method described in Mihajlov and Dimitrijević (1986), appropriated for the helium plasma. All details of the calculations are given in Mihajlov and Dimitrijević (1986, 1992).

In Figs 1 - 2 are presented the absorption coefficients $K_\omega^{(ab)}$ for He_2^+ case as a function of λ and T, for the conditions in white dwarfs atmospheres. If the He^+ ion is present in such amount that the He He^+ product is not negligible the processes



Figures 1,2. The absorption coefficient x 10^{39}[cm^{-1}] as a function of T[K] and λ[A]. The case of He_2^+.

2a and 2b must be treated together in the investigations of the continuum in the astrophysical and laboratory helium plasmas since their contributions are comparable. Moreover, the process 2b becomes more significant towards the infrared part of the spectrum. The total absorption coefficient shows a weak dependence on λ and T except in the region of low temperatures and towards the UV part of the spectrum, where a significant increase of $K_\omega^{(ab)}$ is showed in Figs. 1 - 2 for He_2^+ case.

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D.I.A.M.

DEUXIÈME COLLOQUE
SUR
LA DYNAMIQUE
DES IONS,
DES ATOMES
ET DES MOLÉCULES

BOURGES, 1-3 septembre 1993

STARK BROADENING OF Al III LINES

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By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 23 Al III multiplets . A summary of the formalism is given in Dimitrijević *et al*(1991). Here, we present and discuss the results for Al III multiplets, which are of interest for interpretation and analysis of laboratory and stellar spectra. Namely, Al III absorption lines are very strong in hot star atmospheres (see e.g. Struve, 1930), where Stark broadening is the principal pressure broadening mechanisme. Moreover, results presented may be used for the diagnostic and modelling of an electrodynamic macro-particle accelerator arc plasma created by the evaporation of an Al-foil (see e.g. Rasheigh and Marshall, 1978; or Rolader and Batteh, 1989) and for spectroscopy of laboratory plasma (Davis and Morin, 1971).

In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and ionized helium- impacts have been calculated. A sample of our results for Stark broadening parameters of Al III multiplets is shown in Table 1, for a perturber density of 10^{15} cm^{-3} and temperatures T = 10,000 - 500,000 K. Data for other densities may be provided by authors upon request or obtained from data in Table 1 taking into account that the linearity [illegible] density is not valid when the Debye screening effect becomes important. In such a case, The Debye shielding correction, see p. 321, in Griem (1974), divided by Z^2 must be used. Here, Z = 1, for neutrals, 2 for singly charged ions etc.

Table 1. This table shows electron-, proton-, and ionized- helium- impact broadening parameters for Al III , for a perturber density of 10^{15} cm^{-3} and temperatures from 10,000 to 500,000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By using c [see Eq. (5) in Dimitrijević et al, 1991], we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

PERTURBER DENSITY = 0.1E+16 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 3S-3P	10000.	0.518E-03	-0.140E-05	0.296E-05	-0.599E-06	0.506E-05	-0.599E-06
1857.4 A	20000.	0.371E-03	-0.388E-05	0.676E-05	-0.120E-05	0.983E-05	-0.118E-05
C= 0.19E+19	50000.	0.240E-03	-0.370E-05	0.133E-04	-0.264E-05	0.165E-04	-0.245E-05
	100000.	0.179E-03	-0.397E-05	0.182E-04	-0.399E-05	0.196E-04	-0.352E-05
	200000.	0.142E-03	-0.375E-05	0.208E-04	-0.545E-05	0.221E-04	-0.448E-05
	500000.	0.113E-03	-0.358E-05	0.240E-04	-0.692E-05	0.243E-04	-0.571E-05
ALIII 3S-4P	10000.	0.164E-03	0.145E-05	0.594E-05	0.672E-06	0.803E-05	0.658E-06
696.0 A	20000.	0.122E-03	0.295E-05	0.916E-05	0.123E-05	0.112E-04	0.114E-05
C= 0.85E+17	50000.	0.898E-04	0.258E-05	0.126E-04	0.210E-05	0.136E-04	0.184E-05
	100000.	0.757E-04	0.364E-05	0.142E-04	0.279E-05	0.151E-04	0.231E-05
	200000.	0.660E-04	0.303E-05	0.156E-04	0.334E-05	0.160E-04	0.276E-05
	500000.	0.564E-04	0.286E-05	0.167E-04	0.416E-05	0.167E-04	0.336E-05
ALIII 3S-5P	10000.	0.208E-03	0.136E-04	0.176E-04	0.175E-05	0.215E-04	0.163E-05
560.4 A	20000.	0.166E-03	0.843E-05	0.231E-04	0.281E-05	0.250E-04	0.243E-05
C= 0.25E+17	50000.	0.139E-03	0.794E-05	0.271E-04	0.422E-05	0.289E-04	0.346E-05
	100000.	0.128E-03	0.753E-05	0.298E-04	0.506E-05	0.304E-04	0.418E-05
	200000.	0.119E-03	0.651E-05	0.310E-04	0.601E-05	0.312E-04	0.489E-05
	500000.	0.106E-03	0.575E-05	0.317E-04	0.714E-05	0.318E-04	0.558E-05

D.I.A.M.

DEUXIÈME COLLOQUE
SUR
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DES ATOMES
ET DES MOLÉCULES

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PERTURBER DENSITY = 0.1E+16 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 3P-4S	10000.	0.580E-03	0.116E-03	0.390E-05	0.104E-04	0.526E-05	0.968E-05
1382.6 A	20000.	0.416E-03	0.767E-04	0.106E-04	0.167E-04	0.111E-04	0.145E-04
C= 0.33E+18	50000.	0.286E-03	0.575E-04	0.224E-04	0.252E-04	0.208E-04	0.207E-04
	100000.	0.232E-03	0.491E-04	0.304E-04	0.302E-04	0.270E-04	0.251E-04
	200000.	0.194E-03	0.426E-04	0.385E-04	0.359E-04	0.334E-04	0.291E-04
	500000.	0.158E-03	0.367E-04	0.489E-04	0.429E-04	0.429E-04	0.334E-04
ALIII 3P-5S	10000.	0.412E-03	0.204E-03	0.119E-04	0.208E-04	0.114E-04	0.180E-04
856.2 A	20000.	0.316E-03	0.151E-03	0.216E-04	0.288E-04	0.208E-04	0.242E-04
C= 0.57E+17	50000.	0.259E-03	0.113E-03	0.360E-04	0.370E-04	0.306E-04	0.306E-04
	100000.	0.230E-03	0.874E-04	0.455E-04	0.443E-04	0.382E-04	0.361E-04
	200000.	0.202E-03	0.696E-04	0.559E-04	0.508E-04	0.447E-04	0.417E-04
	500000.	0.169E-03	0.511E-04	0.690E-04	0.602E-04	0.515E-04	0.510E-04
ALIII 3P-3D	10000.	0.451E-03	0.326E-05	0.323E-05	0.122E-05	0.536E-05	0.121E-05
1609.8 A	20000.	0.328E-03	0.628E-05	0.706E-05	0.238E-05	0.996E-05	0.229E-05
C= 0.72E+18	50000.	0.216E-03	0.562E-05	0.132E-04	0.475E-05	0.159E-04	0.415E-05
	100000.	0.165E-03	0.695E-05	0.175E-04	0.661E-05	0.187E-04	0.570E-05
	200000.	0.135E-03	0.596E-05	0.201E-04	0.828E-05	0.210E-04	0.685E-05
	500000.	0.112E-03	0.572E-05	0.233E-04	0.104E-04	0.234E-04	0.849E-05
ALIII 3P-4D	10000.	0.491E-03	0.389E-04	0.218E-04	0.259E-04	0.236E-04	0.226E-04
893.3 A	20000.	0.386E-03	0.427E-04	0.358E-04	0.359E-04	0.345E-04	0.296E-04
C= 0.15E+17	50000.	0.297E-03	0.389E-04	0.512E-04	0.460E-04	0.462E-04	0.381E-04
	100000.	0.251E-03	0.364E-04	0.620E-04	0.537E-04	0.545E-04	0.442E-04
	200000.	0.214E-03	0.303E-04	0.716E-04	0.624E-04	0.640E-04	0.517E-04
	500000.	0.173E-03	0.230E-04	0.874E-04	0.749E-04	0.747E-04	0.607E-04
ALIII 3P-5D	10000.	0.770E-03	0.155E-03	0.745E-04	0.744E-04	0.708E-04	0.611E-04
740.5 A	20000.	0.661E-03	0.134E-03	0.987E-04	0.902E-04	0.878E-04	0.742E-04
C= 0.55E+16	50000.	0.560E-03	0.109E-03	0.128E-03	0.115E-03	0.109E-03	0.918E-04
	100000.	0.498E-03	0.934E-04	0.157E-03	0.132E-03	0.138E-03	0.107E-03
	200000.	0.436E-03	0.728E-04	0.168E-03	0.147E-03	0.146E-03	0.117E-03
	500000.	0.356E-03	0.532E-04	0.198E-03	0.187E-03	0.185E-03	0.131E-03
ALIII 3D-4P	10000.	0.434E-02	0.235E-04	0.124E-03	0.143E-04	0.172E-03	0.141E-04
3606.2 A	20000.	0.327E-02	0.591E-04	0.198E-03	0.267E-04	0.245E-03	0.248E-04
C= 0.23E+19	50000.	0.242E-02	0.533E-04	0.282E-03	0.466E-04	0.305E-03	0.412E-04
	100000.	0.205E-02	0.773E-04	0.320E-03	0.634E-04	0.340E-03	0.519E-04
	200000.	0.180E-02	0.653E-04	0.352E-03	0.763E-04	0.363E-03	0.625E-04
	500000.	0.155E-02	0.614E-04	0.372E-03	0.950E-04	0.379E-03	0.781E-04

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D.I.A.M.

BOURGES,

3, 4, 5 JUILLET 1991

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84- THE INVESTIGATION OF SYSTEMATIC TRENDS IN SPECTRAL SERIES : O VI LINES.

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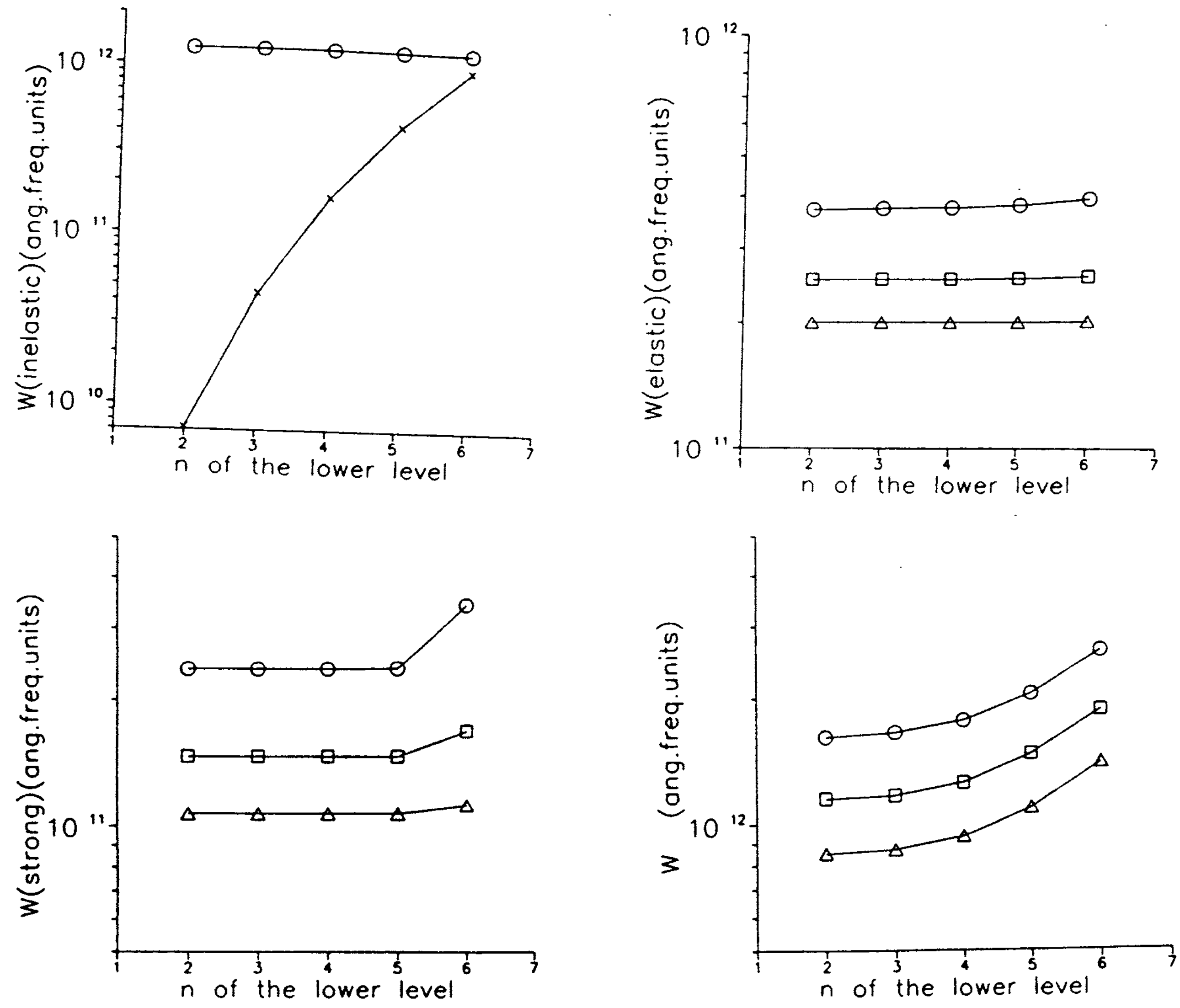
The knowledge of O VI Stark broadening parameters is veryimportant for the investigation of hot dense plasmas in laboratory (see e.g. Böttcher et al, 1988) and in astrophysics (Seaton, 1987), owing to its high cosmical abundance and its presence as an impurity in many laboratory plasma sources. By using the semiclassical-perturbation formalism (Sahal-Bréchot,1969ab) we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 30 O VI multiplets. A summary of the formalism has been recalled in Dimitrijevic et al (1991).

The obtained set of results has also been used for investigations of the behaviour of Stark widths and shifts parameters along spectral series. In a number of papers (see e.g.Dimitrijević and Sahal-Bréchot, 1990 and references therein) it has been demonstrated that within a spectral series Stark linewidths increase in a regular way when the energy level structure is regular and that such trends may be useful for an interpolation of new data and for quick estimations. Here we study the case when when the upper level is constant and the lower level principal quantum number increases. As an example the case of O VI ns - 6p transitions is shown in Figs. 1 - 4.

We can see that the elastic and strong collision contribution to the linewidth change little with the increase of the lower level principal quantum number (n)and that only lower level inelastic collision contribution changes significantly. The resulting linewidths change very little, especially for the lowest n, and the changes are regular in such a manner that an interpolation may provide quite satisfactory accuracy.



Figs.1-4. Electron-impact widths along the O VI ns - 6p series as a function of n for T = 100,000K (O); 1300,000 K (□), and 800,000 K (Δ) at N = 10^{15} cm^{-3} (angular frequency units).

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BOURGES,

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85- THE SEARCH FOR A SIMPLE FORMULA FOR NEUTRAL ATOM BROADENING.

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Regularities and similarities in the widths of spectral lines perturbed by neutral atoms exist and the principal results on the clearly identified regularities have been published recently[1].

The Van der Waals result for the theoretical half-half width, w(theory), has been used in conjunction with the critically selected data of Allard and Kielkopf[2], w(experiment), to study the regularities in transitions along a spectral series and in the corresponding transitions in homologous emitters. The dependence of line widths on the perturber properties has also been examined.

Several possible simple formulae for line widths have been examined all of which contain the long-range polarisation terms in the emitter-perturber interaction and in which the Van der Waals potential is regained in the limit of large interatomic separations R. These formulae are being assessed to determine which one gives the best overall predictions, but they all represent a considerable improvement on the pure Van der Waals formula. The simplest of these is obtained by assuming that the change in the interaction between the perturber and the emitter as a result of a transition from state i to state j is

$$V(R) = -\tfrac{1}{2}\alpha_d\,[(R^2-\overline{r_i^2})^{-2} - (R^2-\overline{r_j^2})^{-2}]$$

where α_d is the polarisability of the perturber and $\overline{r_i^2}$ and $\overline{r_j^2}$ are the mean square radii of states i and j. In the limit of large values of R, V(R) goes over to the Van der Waals formula so that

$$V(R) = -C_6/R^6 \quad ; \qquad C_6 = \alpha_d(\overline{r_i^2} - \overline{r_j^2}).$$

We also define the quantity

$$f(C_6, \mu, T) = C_6^{2/5}(T/\mu)^{3/10},$$

where μ is the reduced mass of the emitter-perturber system, T is the temperature and all quantities are in atomic units. Results for transitions in the alkalis perturbed by rare gases are shown in figures 1-4. The scatter of the data about the average value of w(experiment)/w(theory) is less for larger values of $f(C_6, \mu, T)$, which corresponds to larger values of C_6 and hence to where the longer-range part of the interatomic potential becomes dominant in determining the width. Our results also show that much better agreement between theory and experiment is obtained when the new simple formula is used, since the average value of the ratio is much closer to unity and the spread in the data is also reduced. This improvement can be easily understood. Accurate atom-atom potentials, see figure 6 ref. 1, show that the true Van der Waals limit is only reached when R > 50 a.u., whereas the new formula is approximately valid for much smaller values of R.

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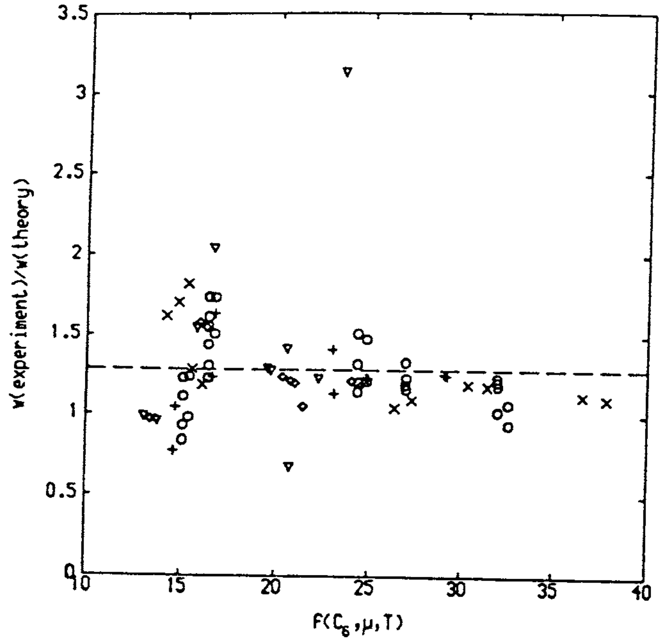

Figure 1

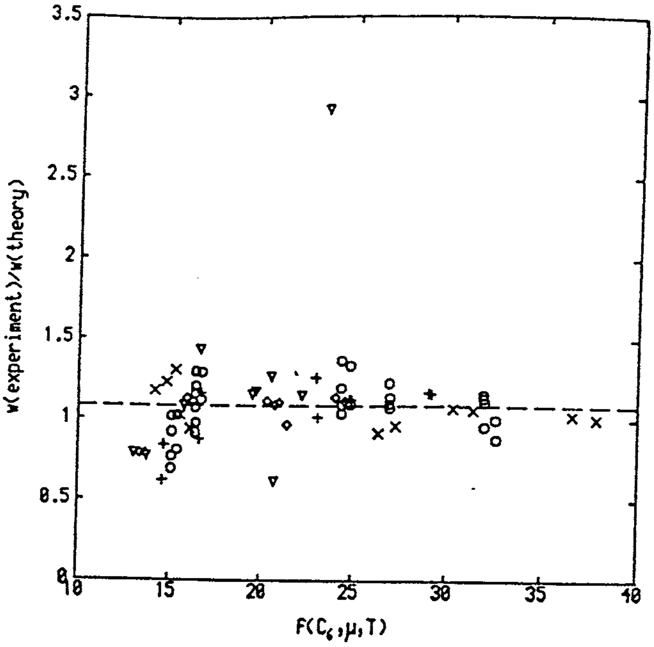

Figure 2

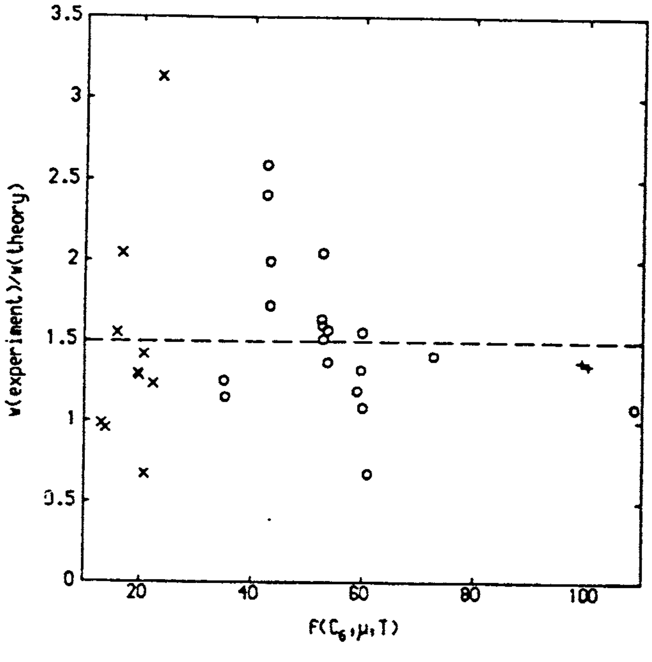

Figure 3

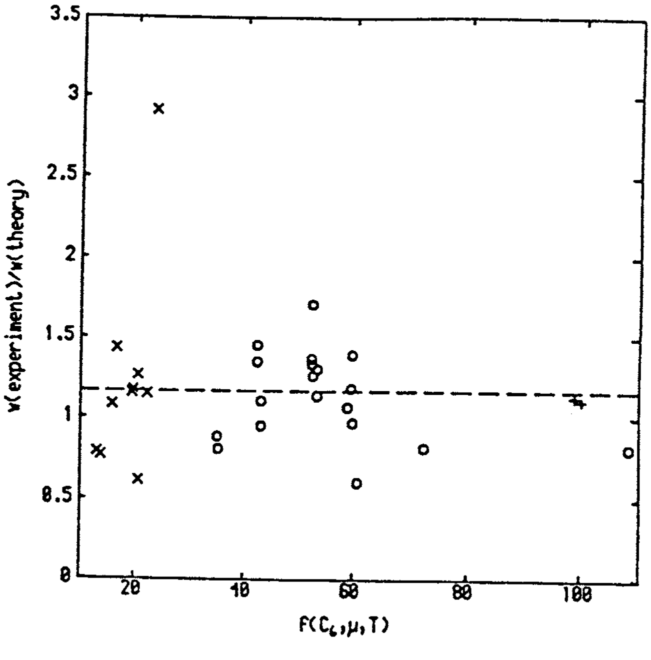

Figure 4

Results for transitions in the alkalis perturbed by the rare gases. In figures 1 and 3 w(theory) is given by the Van der Waals formula and in figures 2 and 4, w(theory) is given by the new simple formula. Figures 1 and 2 show data for resonance transitions of all the alkalis and figures 3 and 4 show data for the spectral series 6s-np, n = 6,7,8 in caesium. The average values of w(experiment)/w(theory) in figures 1-4 are 1.285, 1.082, 1.495 and 1.162 respectively.

Contribution to the Astroinformatics and spectroscopic research: Stark broadening parameters of helium-like boron lines

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This study is oriented to contribute to the theoretical Stark broadening data in STARK-B database catalogue [1], which is a part of VAMDC – Virtual Atomic and Molecular Data Center [2].

Spectroscopic data of boron lines are of interest in astrophysics, astrochemistry and cosmology [3-5]. The cosmic abundance of boron is of major importance for the model of Galactic chemical evolution [6]. To determine reliably the chemical abundance of boron, which is a crucial parameter, one needs an accurate interpretation of the detailed line spectra of the stellar objects. For hot stars, and especially white dwarfs, Stark broadening data are needed for such analysis, as well as for accurate spectroscopic diagnostics and modelling. In this contribution, we present new, theoretically determined, Stark broadening results for B IV, which will be included in STARK-B and VAMDC.

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SERBIAN VIRTUAL OBSERVATORY AND DIGITIZATION

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SerVO - Serbian virtual observatory (http://servo.aob.rs) was founded in 2008, with the objective to publish data obtained by Serbian astronomers as well as to provide astronomers in Serbia with VO tools for their research.

Now, SerVO has seven different sections:

1. Archive of photo-plates from the 1934-1996 period.
2. Link to, and the mirror site in construction of the STARK-B database.
3. Fundamental Catalogues
4. Link to, and the mirror site in construction of the DSED (Dartmouth Stellar Evolution Database) database.
5. Fe II (4000-5500 A) template in AGN spectra.
6. Presentation of the Group for Astrophysical Spectroscopy.
7. Electronic editions of the GAS – Group for Astrophysical Spectroscopy

Development of Archive of photo-plates, Section on Fundamental Catalogues and Section with electronic editions of the GAS are based on digitization of the corresponding photo-plates and publications on Astronomical Observatory in Belgrade, one of the oldest scientific institutions in Serbia, founded in 1887, by Milan Nedeljković.

From the mid-thirties till mid-nineties of the twentieth century, when photographic plates have been one of the recording media for the observations, more than fifteen thousand archived plates exist. Since they have not only a historical, but also and especial scientific importance for astronomy, one of the main objectives of SerVO, is to digitize them and publish in the VO compatible format.

Also several stellar catalogues have been produced in Belgrade and three of them are digitized and included in SerVO, while the digitization of others is in progress.

Group for Astrophysical Spectroscopy started with electronic publishing in in 2006. The majority of books and proceedings of conferences authored or edited by members of this group are now digitized and included in SerVO.

In this key note we will review the present and future work on digitization for Serbian Virtual Observatory.

DIGITIZED ELECTRONIC EDITIONS OF SERBIAN ASTRONOMICAL INSTITUTIONS AND SOCIETIES

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We started with electronic publishing in 2006 on Astronomical Observatory in Belgrade. Some of electronic publications are prepared by us and published in collaboration with other astronomical institutions and Societies, as electronic sources on CDs and DVDs.

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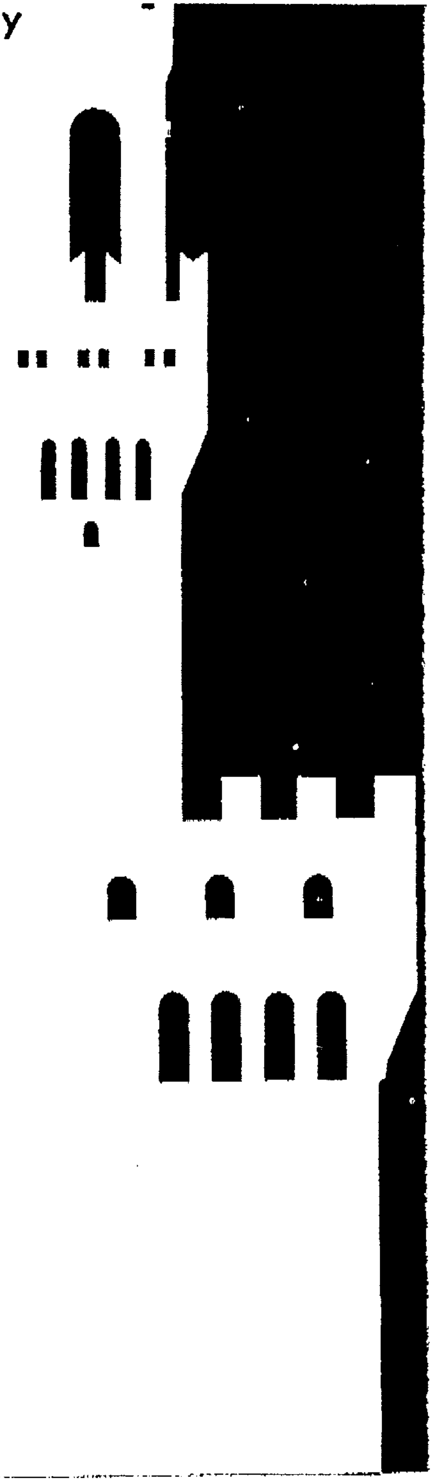

ABSTRACTS

Firenze (Italy)
September 14-17, 1993

SYMPOSIUM 20

Collisions of multiply charged ions with surfaces and gases

F. 1

ON THE STARK BROADENING OF Be I SPECTRAL LINES

M.S.Dimitrijević. Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavia.
S.Sahal-Bréchot, Laboratoire "Astrophysique, Atomes et Molécules", Unité associée au C.N.R.S. No 812, Département Atomes et Molécules en Astrophysique, Observatoire de Paris-Meudon, 92190 Meudon, France.

Beryllium Stark-broadening parameters are important to astrophysicists since the surface content (abundance) of light elements involves problems correlated with nucleogenesis, mixing between the atmosphere and the interior, and stellar structure and evolution. With the developpement of infrared and space astronomy, Stark broadening data for a large number of atom- and ion-spectral lines will be needed. We note that for lines originating from higher energy levels the importance of Stark broadening increases. Such data are useful as well for the diagnostic of laboratory plasmas and for plasma spectroscopy.

By using the semiclassical-perturbation formalism, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 28 Be I multiplets and the resulting data have been compared with existing theoretical values. The agreement is within error limits of the semiclassical method except for transitions involving highly excited levels (2p-4s and 2p-4d) where our widths are smaller due to Debye screening effect not taken into account explicitelly in previous calculations (but the corresponding correction is suggested).

F. 2

INFLUENCE OF ION-MOLECULE-COLLISIONS ON THE HYPERFINEINTERACTION OF 111-Cd-IONS STUDIED BY TIPAC AND TDPAC MEASUREMENTS

S. Kuberczyk, C. Ruth, L. Ziegeler, I. Borchert, 2. Physikalisches Institut, Universität Göttingen, Bunsenstr. 7-9, D 3400 Göttingen

Using the perturbed γ-γ-angular correlation method the hyperfine interaction of ^{111}Cd-ions was studied in gaseous InJ, InCl and $InCl_3$ surroundings by measuring the attenuation coefficients $G_{22}(\infty)$ (time integrated) and $G_{22}(t)$ (time differential). The radioactive decay of ^{111}In in ^{111}InJ, ^{111}InCl and $^{111}InCl_3$ molecules and the following Coulomb explosion of these molecules provided the excited ^{111}Cd-ions. A strong perturbation was found showing a qualitatively similar, but quantitatively different dependence on the character and the density of the surrounding gas. $G_{22}(\infty)$ varied between 0.01 and 0.9 for molecule densities between 10^{14} and 10^{20} molecules/cm^3. Surprisingly the perturbation in the InJ- and InCl-systems vanishes for high densities much faster than in the $InCl_3$-systems.
Using a stochastic model, it is possible to calculate the mean hyperfine frequence ω_0 (116 MHz for InJ, 183 MHz for InCl and 540 MHz for $InCl_3$), and to estimate the cross-sections for molecule-ion collisions at sub eV energies. Some considerationes are presented to explain the unexpected effect.

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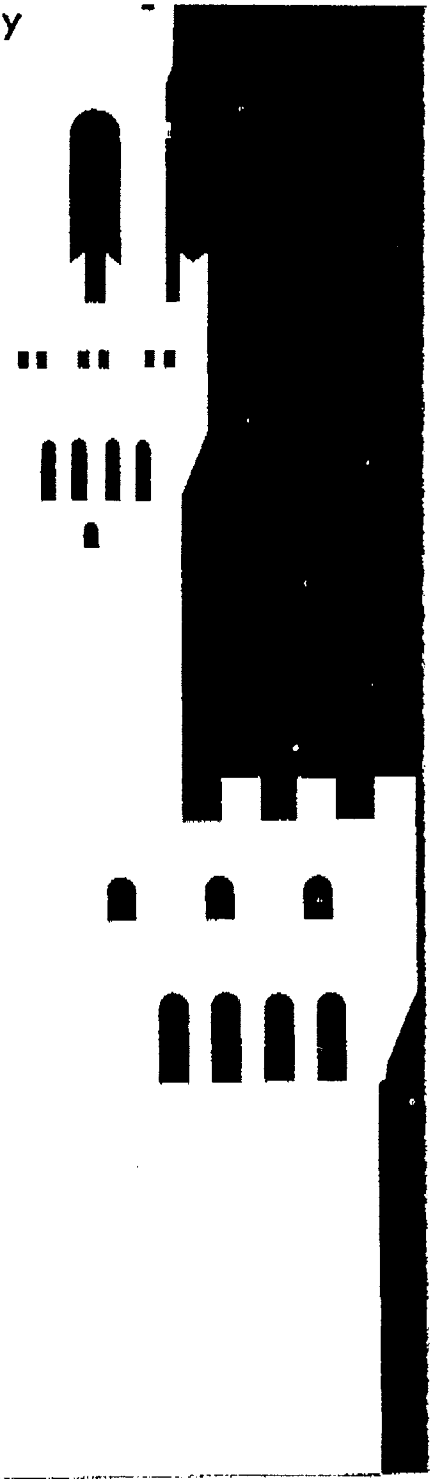

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ABSTRACTS

Firenze (Italy)
September 14-17, 1993

MULTIFRAGMENT EMISSION IN THE REACTION OF ^{238}U ON Ag AT 15 MeV/NUCLEON

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Z. Todorović, Institute of Physics, 11000 Belgrade, Yugoslavia.
M. Zamani, D. Sampsonidis, University of Thessaloniki, Nuclear Physics Department, 54006 Thessaloniki, Greece.
M. Debeauvais, J. Ralarosy, Centre de Recherches Nucléaires, 23, Rue du Loess, 67037 Strasbourg, France.
F. Fernandez, Universidad Autónoma de Barcelona, Barcelona, Spain.

CR-39 detectors have been used to study the reaction ^{238}U+ Ag at 15 MeV/nucleon in a 2π geometry. The experimental cross sections for four- and five- pronged events have been determined. Results of the kinematical analysis for four-pronged events support deep inelastic reaction with a three-step process in the 85% of the total number of four-pronged events. Other four-pronged events could be explained as a quasi-fission process i.e. as a two-step process. Kinematical analysis for five-pronged events indicates a three-step process in all examined events. The mass transfer between the projectile and target nucleus in the first reaction step has been estimated with the Fokker-Planck equation. Experimental results and solutions of the Fokker-Planck equation for four- and five-pronged events indicate a important drift of nucleons from target to the projectile nucleus in the first reaction step.

F. 10

ON THE INFLUENCE OF RADIATOR COMPLEXITY TO STARK BROADENING

Milan S. Dimitrijević, Luka Č. Popović, Astronomical Observatory, Volgina 7, 11050 Belgrade, Yugoslavia.

Using a modified semiempirical approach [1], we have calculated Stark broadening parameters of Zn II, Br II, Cd II, and Bi II spectral lines as a function of temperature. The influence of the oscillator stength accuracy on Stark parameter calculation has been investigated (for Zn II, Br II and Cd II). For Bi II spectral lines the configuration mixing (the departure from LS coupling) influence has been investigated as well.

Our results for Stark widths and shifts have been compared with available experimental data. Differences in oscillator strength values produce changes in Stark broadening parameters within the error bars of the method, but in the case of the shift the accuracy of oscillator strengths may be very important. We can conclude that shifts are more sensitive to the oscillator strength accuracy than widths. Consequently, obtained shifts are less accurate than width ones.

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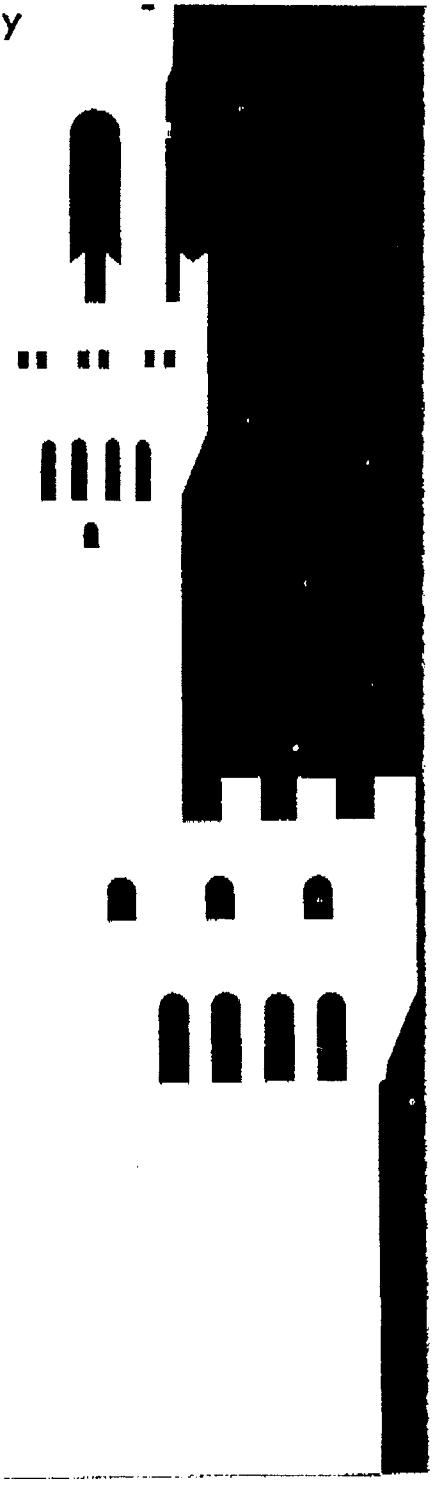
ABSTRACTS



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W. 7

STARK BROADENING OF F VII SPECTRAL LINES

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S.Sahal-Bréchot, Laboratoire "Astrophysique, Atomes et Molécules"Département Atomes et Molécules en Astrophysique Unité associée au C.N.R.S. N 812 Observatoire de Paris-Meudon, 92190 Meudon, France

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), we have calculated electron-, proton- and He III- impact line widths and shifts for 20 F VII multiplets. Obtained results for $3s^2S-3p^2P^o$ multiplet have been compared with existing experimental data (Glenzer et al 1992) and with other calculations (Glenzer et al 1992) by using different approximate approaches. We found the good agreement between experiment and semiclassical calculations as well as the reasonable agreement between different approximate approaches and more sophysticated semiclassical calculations.

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W. 8

SPATIAL SOLITONS FROM GAUSSIAN BEAMS IN KERR MEDIA

D.Burak, W.Samborski, W.Nasalski, Institute of Fundamental Technological Research, Polish Academy of Sciences, Swietokrzyska 21, PL-00-049 Warsaw, Poland.

We present a detailed analysis of generation and propagation of soliton beams in nonlinear Kerr media, where an input beam is assumed to be of Gaussian or soliton form. The problem is solved by use of the Insverse Scattering Transform. The analysis of the discrete spectrum obtained from the Direct Scattering Problem give an exact information about the parameters of the soliton generated. We have found the case that within the error range of numerical calculation all energy of the Gaussian beam entering Kerr medium is transformed into the soliton beam. However, this analogy to selftrapping of soliton beams occurs for higher energy levels than in the case of soliton input profile. Moreover, we formulate numerically the condition of one- and two- soliton presence in the spectrum of the total field. The similarities and differences between soliton and Gaussian beams entering Kerr medium are analysed in details. We propose the novel (to our knowledge) numerical method to solve the nonlinear Schroedinger equation based on the Inverse Scattering Transform.

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TRENDS IN PHYSICS

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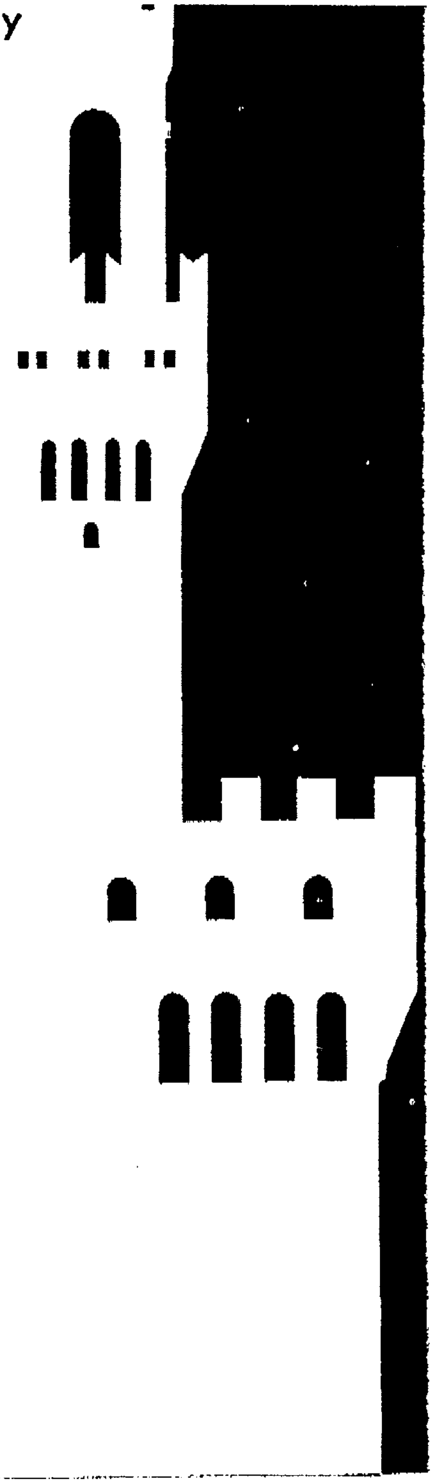

Firenze (Italy)
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W. 11

FIELD DEPENDENT EFFECTS IN A QUADRATIC NONLINEAR MEDIUM

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Univ.Roma I-Via Scarpa 16 00161 ROMA- ITALY

The nonlinear phase distortion that arises from second-order processes in noncentrosimmetric crystal has been object of investigation since 1972.There has been recently a renewed interest mainly in connection with the application for self compression of ultrashort pulses in the presence of positive group velocity dispersion and for devices operating with the self-phase modulation effect.The nonlinear phase distortion in second harmonic generation (SHG) has been considered responsible for the so called "cascading" effect ,which affects the pump beam, introducing a phase shift proportional to its intensivity.In the present paper,a numerical analysis is presented which shows that, under c.w. operation,field dependent effects,such as the nonlinear phase shift (intensity dependent) along the propagation direction (z-axis),appear in all the field possessing a non zero amplitude at the input of the medium. The influence of the initial conditions,as the relative values of the input amplitude, on the conversion efficiency is discussed.Moreover the influence of initial polarizations,under suitable conditions,is also considered.

W. 12

RADIATIVE ION-ATOM COLLISIONS AS A SOURCE OF CONTINUAL EM-RADIATION FROM LOW TEMPERATURE HELIUM PLASMA

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We show that the processess $He + He^+ \rightarrow He + He^+ + \hbar\omega$ and $He^+ + He \rightarrow He_2^+ + \hbar\omega$ must be treated as a source of continual electro-magnetic radiation from low temperature plasma. Both reaction channels are treated separately and the corresponding total and partial spectral coefficients have been calculated for helium plasma at $T \leq 3\ 10^4$ K. The obtained results have been also compared with the corresponding spectral densities for electron-atom and electron-ion scattering.

The presented results show that in the case of helium plasma one must particularly be carefull concerning the continuous EM-radiation spectrum nature. Namely, from our results follows that at typical values of electron and atom component ratio in helium plasma, the investigated radiation processes might be of importance for the determination of the character of spontaneous EM-radiation spectrum.

Besides the interest for laboratory plasma, our results are of interest for research of different types of helium rich stars, particularly those where hydrogen is burnt up and as e.g. for DB white dwarfs.

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EVOLUTION OF STARS: THE PHOTOSPHERIC ABUNDANCE CONNECTION

POSTER PAPERS PRESENTED AT THE 145TH SYMPOSIUM OF THE
INTERNATIONAL ASTRONOMICAL UNION
HELD IN ZLATNI PJASACI (GOLDEN SANDS), BULGARIA
AUGUST 27-31, 1990

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STARK BROADENING OF C IV λ1549 LINES AND CARBON ABUNDANCE IN HOT DA WHITE DWARFS

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1. INTRODUCTION

High resolution IUE spectra of hot DA white dwarfs reveal presence of absorption lines of multiply charged metalic ions (e.g. Bruhweiler and Kondo, 1983). Although they appear in very hot stellar atmospheres, these lines are strongly influenced by pressure broadening (e.g. Kršljanin, 1989). Observed chemical impurities of hot white dwarfs atmospheres are probably due to radiative levitation. To investigate complex processes in strong radiation fields of these stars, as well as previous stages of their evolution, one needs precise abundance determinations. In order to make such determinations easier Henry et al. (1985) calculated equivalent widths of eight most important lines of C, N, Si and Mg ions in spectra of hot DA white dwarfs with log g = 8 for a range of effective temperatures and elemental abundances. They used old semiclassical Stark broadening calculations of Sahal-Bréchot and Segre (1971) performed only for temperatures up to 40000 K. Recently, new accurate close coupling quantum mechanical (Seaton, 1988) as well as semiclassical (resonances included, Dimitrijević and Sahal-Bréchot, 1990) Stark broadening calculations of C IV 2s-2p lines have been published. We used these data to investigate the importance of accurate Stark broadening parameters for abunadance determinations in hot DA white dwarfs.

2. METHOD

We used electron-impact line widths of Seaton (1988) and Dimitrijević and Sahal-Bréchot (1990). These two sets of data differ about 50-60%. For proton-impact width contribution we used only data of Dimitrijević and Sahal-Bréchot (1990). We calculated equivalent widths of C IV λ1549 resonance doublet in pure hydrogen, LTE, log g = 8, H-line blanketed model atmospheres of Wesemael et al. (1980). Ionization balance was calculated according to Traving et al. (1966). Synthesis of line profiles was performed using LTE code of Krsljanin and Vince (1986). Line wings were calculated without limits until the convergence of equivalent widths. All calculations were performed in effective temperature range 20000 K $\leq$ Teff $\leq$ 100000 K and for carbon abundances $-7 \leq \log [\,N(C)/N(H)\,] \leq -3$.

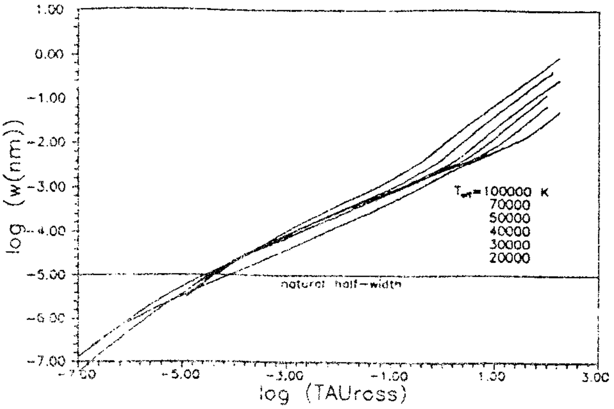

Fig.1. C IV 2s-2p Stark halfwidths in atmospheres of hot DA white dwarfs with log g= 8. Electron-impact widths are according to Seaton (1988).

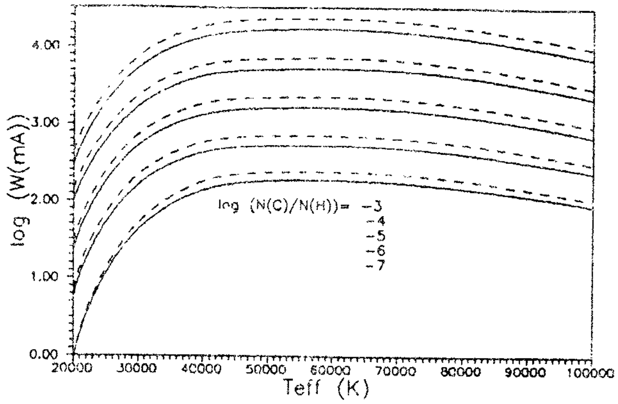

Fig.2. Equivalent width of C IV λ1549A doublet in spectra of hot DA white dwarfs with log g= 8 as a function of effective temperature and carbon abundance. Solid lines - Stark broadening according to Seaton (1988); dashed lines - according to Dimitrijević and Sahal-Bréchot (1990).

3. RESULTS

Typical values of Stark widths based on Seaton (1988) data set in the atmospheres considered are shown in Fig.1. Equivalent widths obtained are shown, in logarithmic scale, in Fig.2. Our results show that typical difference in Stark widths of 60% produces up to 30% difference in equivalent widths and up to 50% difference in abundance.

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ON THE APPROXIMATE METHODS FOR STARK BROADENING CALCULATIONS

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11050 Beograd, Yugoslavia

Data on line profiles broadened by charged particles often are of importance in astrophysics as e.g. for the stellar abundance determinations. Whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important, simple approximative formulae with good average accuracy may be very useful. Moreover, in the case of more complex atoms or multiply charged ions the lack of the accurate atomic data needed for more sophysticated calculations, makes that the reliability of the semiclassical results decreases. In such cases approximate methods might be very interesting.

We might devide all approximate methods for calculations of Stark broadening parameters in the three groups. In the first one are methods where the most complicated part of the calculation, the cross sections for the corresponding dipole transitions are calculated using averaged experimental (e.g. Griem, 1968; Dimitrijević and Konjević, 1980; 1981; 1987; Dimitrijević and Kršljanin, 1986; Dimitrijević, 1988) or theoretical (Seaton, 1987) data. In the second group, one might put methods where the most complicated part is obtained by the symplifications in the more sophysticated theory (e.g. Griem, 1974; Hey and Bryan, 1977) or e.g. by interpolation between theoretically simpler limits (e.g. Dimitrijević and Konjević, 1986). In the third group are the possibilities for the interpolation of new data by using regularities and systematic trends (e.g. Wiese and Konjević, 1982; Dimitrijević and Peach, 1990; Dimitrijević, 1985; Dimitrijević and Popović, 1989; Purić, Lakićević, Glavonić, 1980; Lakićević, and Purić, 1983; Vitel et al., 1988; Djeniže et al., 1990).

For the astrophysical purposes, of particular interest might be the symplified semiempirical formula (Dimitrijević and Konjević, 1987), applicable in the cases when the nearest atomic energy level (j′=i′or f′)where a dipolly allowed transition can occur from or to initial (i) or final (f) energy level of the considered line, is so far, that the condition $x_{jj'} = E/|E_{j'} - E_j| \leq 2$ is satisfied. In such a cases full width at half maximum is given by the expression (Dimitrijević and Konjević, 1987):

$$W(\AA) = 2.2151\ 10^{-8}\ \frac{\lambda^2(cm)\,N(cm^{-3})}{T^{1/2}(K)}\ (0.9 - \frac{1.1}{Z})\ .$$
$$\sum_{j=i,f}\left(\frac{3n_j}{2Z}\right)^2 (n_j^2 - \ell_j^2 - \ell_j - 1)$$

Here, N and T are the electron density and temperature respectively, E = 3kT/2 is the energy of perturbing electron, Z-1 is the ionic charge and n the effective principal quantum number. This expression is of interest for abundance calculations since the validity conditions are often satysfied for stellar plasma conditions.

When the symplified semiempirical formula is not applicable, the good possibilities gives the modified semiempirical method (Dimitrijević and Konjević, 1980; 1981; 1987; Dimitrijević and Kršljanin, 1986, Dimitrijević, 1988), tested several times on the numerous examples of singly-, doubly-, and triply-charged ions (see e.g. Dimitrijević, 1990).

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percentage of second-generation stars would have been quite small (up to ~10 per cent). Such a large fraction of extreme second-generation stars implies that the system must have been initially much more massive and in different dynamical conditions from what it is today. We discuss this issue in the light of existing models of the formation of multiple populations in globular clusters.

Atomic and molecular data for stellar plasma resarch: virtual atomic and molecular data center (VAMDC) and Star-K database

M. Dimitrijevic, S. Sahal-Brechot, D. Jevremovic, A. Kovacevic, L. Popovic, and VADMC consortium (P.I. Marie-Lise Dubernet)

A large number of atomic and molecular data is needed for stellar plasma investigations and for stellar spectra interpretation, synthesis and analysis. The main objective of Virtual Atomic and Molecular Data Center (VAMDC - Dubernet et al., 2010, Rixon et al., 2011), a FP7 funded project, is to enable an efficacious and adequate search and mining of AM data, and consequently, their easier and more adequate use.

In VAMDC will enter also STARK-B database, containing Stark broadening parameters for a large number of lines, obtained by the semiclassical perturbation method. We will present and discuss here the VAMDC project and STARK-B database.

The updated Pisa evolutionary model database

Scilla Degl'Innocenti (Physics Department, Pisa University, Italy); Valle, Tognelli, Dell'Omodarme, Degl'Innocenti, Prada Moroni

Updated tracks and isochrones for evolutionary phases from the PMS to the AGB phase (available at the link: http://astro.df.unipi.it/stellar-models) are presented and compared with other models available in the literature.

Present stellar models and isochrones are calculated by adopting a well-tested evolutionary code (FRANEC) implemented with updated physical and chemical inputs. In particular, our code adopts realistic atmosphere models and an updated equation of state, nuclear reaction rates and opacities calculated with recent solar elements mixture.

Abundance and kinematic analyses of the CH star CD-62°1346

Natalia Drake (Sobolev Astronomical Institute); C.B. Pereira, E.G. Jilinski, N.A. Drake, D.B. Castro,V.G. Ortega, C. Chavero, F. Roig

We report on the results of the detailed spectroscopic and kinematic analyses of the high-velocity carbon-enriched metal-poor ([Fe/H]=-1.59) star CD-62°1346. High-resolution spectrum of this star was obtained with the FEROS echelle spectrograph at the 2.2m ESO telescope at La Silla, Chile. We derived abundances of 18 chemical elements and showed that CD-62°1346 has enhanced carbon and s-element abundances ([C/Fe]=+0.86 and [Ba/Fe]=+1.58) typical for CH stars. CD-62°1346 is also a ``lead" star with [Pb/Ce]=+0.80.

Detailed kinematic analysis based on dynamical calculations, showed that CD-62°1346 is on a highly eccentric retrograde orbit (V_phi ~ -540 km/s; e=0.91) traveling up to about 100 ~ kpc from the Galactic center. The extreme retrograde motion may suggest that CD-62°1346 has an extragalactic origin. However, the high α-element abundances, typical for halo stars of such metallicity, do not support this suggestion. The Galactic rest frame velocity ($V_ GRF ~ 570 km/s), close to the Galaxy escape velocity, indicates that the star may be bound or unbound according to the adopted Galactic potential. The possibility of CD-62°1346, an evolved red giant star, to join the restricted group of hypervelocity stars, formerly consisted of B-type stars only, is discussed.

OB Associations and larger scale stellar structures in six HST spiral galaxies

Petros Drazinos (National and Kapodistrian University of Athens); E.Kontizas, A. Karampelas, M.Kontizas

The presence of small and large-scale star formation structures in a sample of spiral Hubble Space Telescope (HST) galaxies has been investigated. Our main goal is to identify small

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In the PLS framework, at Roma Tre University we developed an itinerant educational laboratory based on meteorites analysis by means of a portable kit. The activity is performed at school and the students are directly involved in the study of meteorite features and in measurements of physical properties of the samples. Students are intriguingly introduced in the scientific method working together in acquisition and analysis of data, and writing a final report.

Lessons and laboratories were developed in collaboration between researchers and high school teachers. Thanks to their multidisciplinary character the activities represent an excellent tool for stimulating the interest in different fields of science as astronomy, physics, geology and biology.

Society of Astronomers of Serbia and Education and Popularisation of Astronomy

***Milan S. Dimitrijevic*[1]*, Andjelka Kovacevic*[2]**
[1]*Astronomical Observatory, Belgrade, Serbia,* [2]*Faculty of Mathematics, Belgrade, Serbia*

The main activities of Society of Astronomers of Serbia within the period October 2008 – June 2012 are: International Year of Astronomy 2009; Astronomical Olympiads; Mobile Planetarium and the Project “Popularization of Astronomy in educational institutions and schools”; Scientific meetings in organization of SAS; Publishing activities of SAS; Foreign scientists – guests of SAS; Connections with European Astronomical Society; Connections with International Astronomical Union.

In this contribution we will focus our attention first of all on the activities of interest for education and popularization of astronomy and to the legacy aspects of IYA2009.

Being Born in 2009 – the Responsibility of a Living Legacy of IYA2009.

Rosa Doran (NUCLIO / GHOU / GTTP, Portugal)

The Galileo Teacher Training Program (GTTP) was one of the cornerstones of IYA2009. Since the ephemeris GTTP have reached over 10 000 educators around the globe. How to maintain the achieved successes? How to face the different challenges in the different parts of the globe ensuring the same rights and access for cutting edge science education tools and resources ? How to ensure no student will have to face the growing digital divide? How to provide equal support for educators from all over the world in a fair and sustainable environment? This and other equally important challenges are already written in the next chapters of these program goals.

With programs like “Discover the Cosmos” and “Open Discovery Space”, such opportunities will flourish and the introduction of cutting edge science in classrooms will be literally at a distance of a click. These European Commission funded projects will help educators change the way they deliver knowledge by engaging students in the path of discovery. This new vision for science education being seeded in Europe can set the tone for a new relation between content and the learning path.

This type of tools associated with GTTP network construction model will ensure that these opportunities will reach a broad audience and a rich repertory of success stories will certainly feel the pages ahead.

Social-Astronomy in Italy and in Europe

***Livia Giacomini* (INAF – IAPS Roma, Italy)*, Elisa Nichelli* (INAF – IAPS Roma, Italy)**

The world has entered a Web 2.0 era. Facebook, Twitter, blogs, wikis, photo and video sharing sites: all these tools are web applications that allow information sharing and the spreading of user-centered design and user-generated content all over the World Wide Web. Every day, the use of these social tools is spreading all over the world, evolving very quickly and with a non homogeneous speed all over Europe.

This social media and networking approach has been studied and largely developed for marketing purposes. But is there all there is? Is this approach beginning to be used to engage the public in Science and in particular in Astronomy? Are social media becoming useful tools to popularize science, research and scientific results to a larger public?

In this work we will present an overview of how social media are used in Italy and all over Europe to involve the public in Astronomy and Space Science. To reach this goal we will start

EWASS 2012 - SYMPOSIUM 6

ABSTRACTS BOOKLET

Last Updated on Jun 22nd, 2012

Milan Dimitrijevic

Astronomical Observatory, Serbia

Atomic and molecular data for stellar plasma resarch: virtual atomic and molecular data center (VAMDC) and Star-K database

Authors: M. Dimitrijevic, S. Sahal-Brechot, D. Jevremovic, A. Kovacevic, L. Popovic, and VADMC consortium (P.I. Marie-Lise Dubernet

Abstract: A Large number of atomic and molecular data is needed for stellar plasma investigations and for stellar spectra interpretation, synthesis and analysis. The main objective of Virtual Atomic and Molecular Data Center (VAMDC - Dubernet et al., 2010, Rixon et al., 2011), a FP7 funded project, is to enable an efficacious and adequate search and mining of AM data, and consequently, their easier and more adequate use. In VAMDC will enter also STARK-B database, containing Stark broadening parameters for a Large number of lines, obtained by the semiclassical perturbation method. We will present and discuss here the VAMDC project and STARK-B database.

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Институт теплофизики экстремальных состояний РАН

Институт электрофизики и электроэнергетики РАН

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Том первый

Секции:

Элементарные процессы в плазме
Диагностика плазмы
Кинетика низкотемпературной плазмы
Компьютерное моделирование НТП
Приложения НТП

THE INFLUENCE OF THE RESONANT NON-ELASTIC ATOM-RYDBERG ATOM COLLISION PROCESSES ON THE CHARACTERISTICS OF WEAKLY IONIZED PLASMA

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Introduction

In this work the chemi-ionization processes in symmetric atom-Rydberg atom collisions, as well as the inverse chemi-recombination processes, there are in the centre of attention. Here we keep in mind the atom-atom collision ionization processes

$$A^*(n) + A \rightarrow e_k + A^+ + A \tag{1}$$

$$A^*(n) + A \rightarrow e_k + A_2^+ \tag{2}$$

and corresponding electron-ion-atom recombination processes

$$e_k + A^+ + A \rightarrow A^*(n) + A \tag{3}$$

$$e_k + A_2^+ \rightarrow A^*(n) + A \tag{4}$$

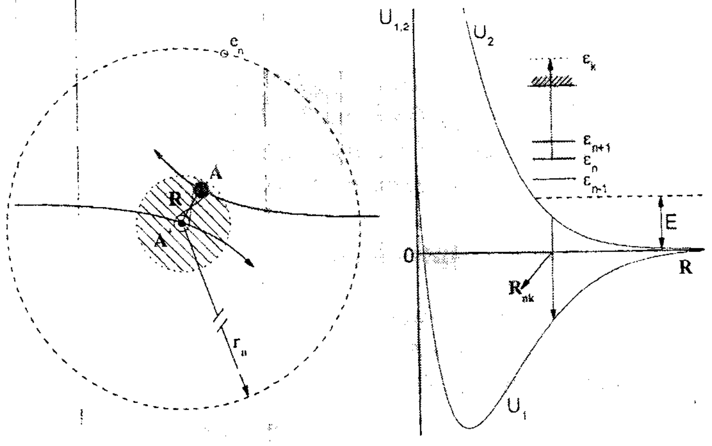
where $A^*(n)$ is an atom in the highly excited (Rydberg) state with the principal quantum number $n >> 1$, A and A^+ – the corresponding parents atom and its positive ion in their ground states, A_2^+ – the molecular ion in the ground electronic state, and e_k – the free electron with energy ε_k. In the previous period primarily the processes (1) and (2), in the cases when A is an alkali atom, were investigated [1–16]. Apart of that, the processes (1)–(4), in the cases when $A = H$ and He, were investigated also [17–19]. All chemi-ionization processes were treated by means of semi-classical method based on the mechanism of the resonant energy exchange within the electron component of the considered collision system, introduced into consideration in [20]. This mechanism is illustrated by Fig. 1, where U_1 and U_2 denote the potential curves of the ground and the first excited electronic state of molecular ion A_2^+. First of all, the mentioned papers were devoted to determination of the cross-sections and the corresponding rate-coefficients for the processes (1)–(4).

Beside of chemi-ionization and chemi-recombination processes, the processes of (n-n')-mixing in symmetric atom-Rydberg atom collisions, namely

$$A^*(n) + A \rightarrow \begin{cases} A^*(n+p) + A, \\ A + A^*(n+p), \end{cases} \tag{5}$$

$$A^*(n) + A \rightarrow \begin{cases} A^*(n-p) + A, \\ A + A^*(n-p), \end{cases} \tag{6}$$

where $p \geq 1$, were investigated in previous period, but only sporadically. Here we will mention only two papers where the mentioned resonant mechanism was introduces and studied [20, 21]. The main aim of these papers was also determination of the corresponding cross-sections.



(a) (b)

Fig. 1. (a) Schematic illustration of $A^*(n) + A$ collision (the region of the inter-nuclear distance R where the outer electron is collectivized is shaded); (b) Schematic illustration of the simultaneous resonant transitions of the outer electron from the initial bound to the final free state and the sub-system $A^+ + A$ from initial excited to the final ground electronic state

In the last few years significant attention was devoted to the investigation of processes (1)–(6) from the aspect of their influence to inner-plasma kinetics and optical characteristics of weakly-ionized laboratory and astrophysics gaseous plasmas. Just from such an aspect these processes are considered in this work.

Results and discussion

Recently, in [22] was presented the significance of processes (1)–(4) with $A = Na$ for different astrophysical plasmas and for so called photo-resonant plasmas (see also [23]). In [22] it was suggested that for the applications of processes (1)–(4) in the cases of alkali atoms one should use the rate coefficients determined in [12] and [16], while in the case of $A = H$ and He – the rate coefficients determined in [18] and [19]. In connection let us draw attention that the rate coefficients from [18] and [19] were already applied for the solar photosphere and for photospheres of some DB white dwarfs, where it was noticed that the processes (1)–(4) with $A = H$ and He dominate in comparison with other relevant ionization-recombination processes [24, 25]. Because of that, the influence of that processes with $A = H$ on $H^*(n)$ atom populations was investigated by means of code PHOENIX in the case of photosphereM dwarfs [26]. Major result of this work is that including of the processes (1)-(4) in the model changes the calculated values of the mentioned populations up to 50 %. This is illustrated by Fig. 2 which shows the behavior of the quantity $\zeta(n)$, i. e. the ratio of the populations calculated with and without inclusion of chemi-ionization and chemi-recombination processes. Since these processes, influence also to the electron density in the considered photosphere, they should influence simultaneously to the intensities and the shapes of hydrogen spectral lines. This impressive confirms the results shown in Figs. 3a and 3b, which relate to the shapes of H_ε and Pa_ε lines determined with and without of processes (1)–(4).

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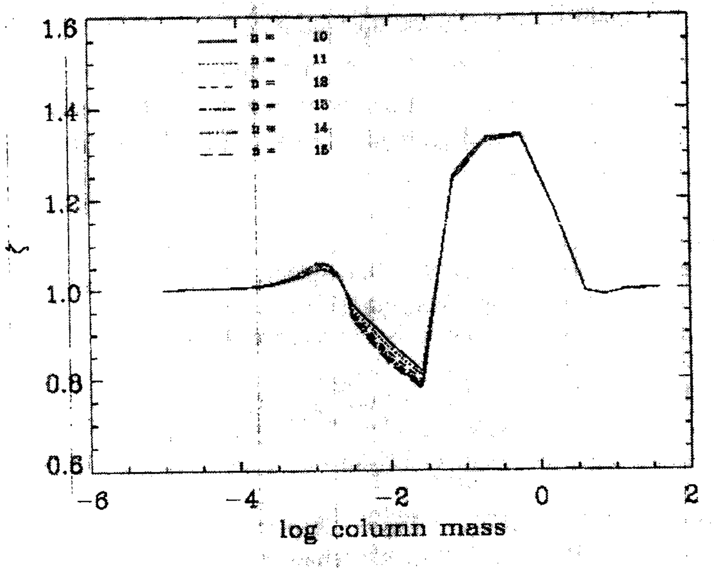

Fig. 2. The behaviour of the population ratio $\zeta(n)$ for $10 \le n \le 15$ as a function of the column mass

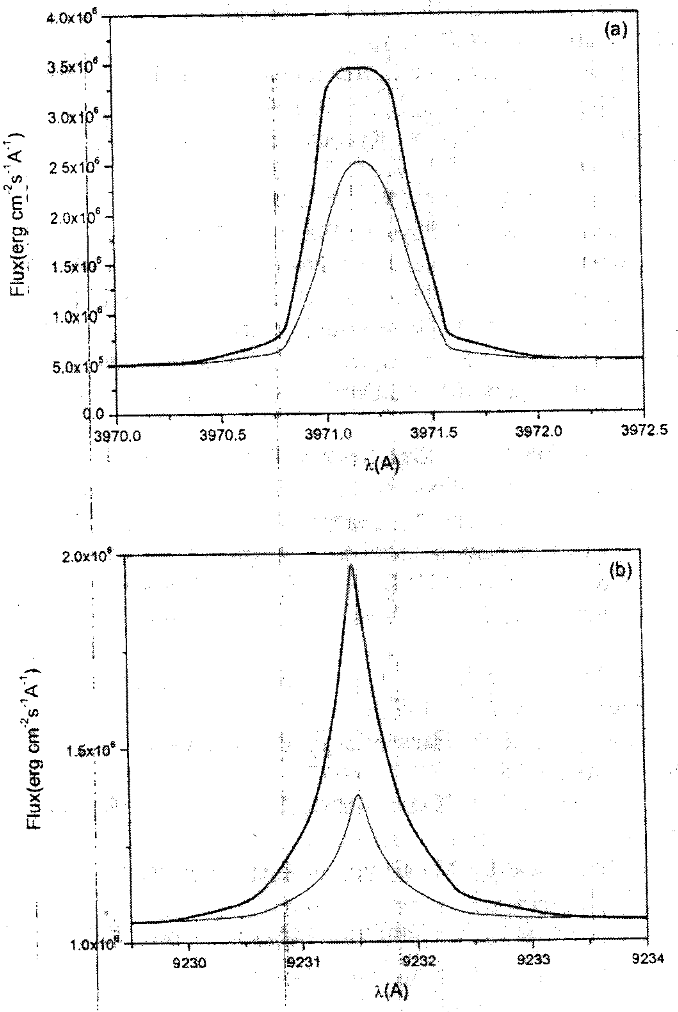

Fig. 3. Line profiles with (wide) and without (thin) inclusion of chemi-ionization and chemi-recombination processes for H_ε (a) and Pa_ε (b) lines from the atmosphere described in text

Apart of above mentioned one should add that in the last time are obtained first results in connection with the processes (5) and (6) of (n-n')-mixing in $H^*(n)+H$ collisions, which suggest that these processes could significantly influence to the distribution of excited states atom populations in weakly ionized hydrogen plasmas [28]. Some later, this was confirmed for the case of solar photosphere [29].

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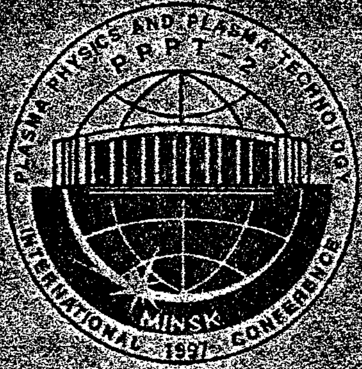

ФИЗИКА ПЛАЗМЫ И ПЛАЗМЕННЫЕ ТЕХНОЛОГИИ

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THE ELECTRON IMPACT PARAMETERS FOR Na II LINES

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Serbia, Yugoslavia

Introduction

Stark broadening data for many physical and astrophysical problems as the plasma diagnostic, investigation of laser produced plasma, the calculation of stellar opacities, abundance determination, interpretation and investigation of stellar spectra etc. are needed.

Very often one has to calculate Strak broadening data for emitters with complex spectra, where the usual LS coupling scheme is not applicable as well as more sophisticated methods as the quantum mechanical approach or the semiclasical approach [1,2] due to lack of atomic data. Than, the simpler methods for Stark broadening parameter calculations as the modified semiempirical approach can be used [3-5]. In Refs. [5-8] it was shown that for an emitter with the complex spectrum, the modified semiempirical approach gives a good average accuracy.

Here we present Stark broadening parameters for Na II 3s-3p transition. Calculations were performed using the modified semiempirical approach. Also, using the designation of atomic energy levels from Ref. [9] we have calculated the corresponding Stark broadening parameters assuming the LS and the $J\ell$ coupling approximation.

Results and discussion

The atomic energy levels have been taken from Ref. [9]. The necessary matrix elements have been calculated within the Columb approximation as in Ref. 5

In Table 1 and 2 we present results of our calculation of Stark widths and shifts for Na II 3s-3p transitions assuming the LS and $J\ell$ coupling approximation, respectively.

In Figs. 1 and 2 we have compared the Stark widths and shifts for the λ =313.55 nm and the 292.09 nm obtained assuming these two coupling approximations.

Table 1. Stark width (FWHM) and shift of Na II (3s-3p) transitions for electron density of $10^{23}\mathrm{m}^{-3}$ as a function of temperature. The averaged wavelength of the multiplet is denoted as $\overline{\lambda}$. The $J\ell$ coupling approximation was assumed.

Transition	T (K)	W (nm)	d (nm)
$3s(^2P^0_{1/2})\ ^2[1/2]^0 - 3p^2[1/2]$ $\overline{\lambda} = 309.84$ nm	5000.	.147E-01	-.137E-02
	10000.	.102E-01	-.970E-03
	20000.	.707E-02	-.686E-03
	30000.	.572E-02	-.560E-03
	40000.	.497E-02	-.480E-03
	50000.	.451E-02	-.430E-03
$3s(^2P^0_{1/2})\ ^2[1/2]^0 - 3p^2[3/2]$ $\overline{\lambda} = 320.16$ nm	5000.	.154E-01	-.136E-02
	10000.	.107E-01	-.960E-03
	20000.	.743E-02	-.681E-03
	30000.	.602E-02	-.558E-03
	40000.	.523E-02	-.480E-03
	50000.	.474E-02	-.434E-03

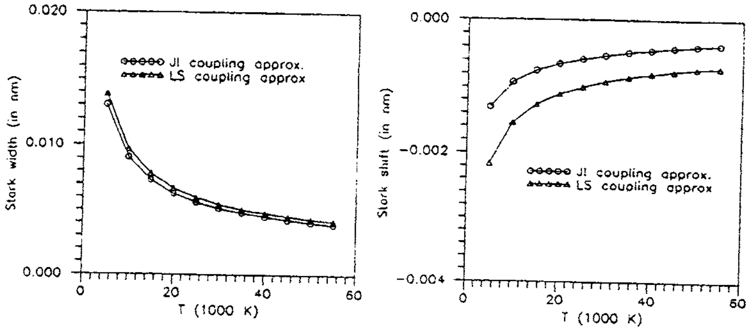

Fig. 1. Comparison of Stark full width (FWHM) (left) and shift (right) for the two coupling approximations as a function of temperature. The calculation for Na II λ=313.55 nm ($3s^3P^0_0 - 3p^3D_1$ – notation within the LS coupling scheme; $3s[1/2]^0_0 - 3p[3/2]_1$ – notation within the $J\ell$ coupling scheme) was done. The electron density is $10^{23}\mathrm{m}^{-3}$.

Table 2. Same as in Table 1, but within the *LS* coupling approximation was assumed.

Transition	T (K)	W (nm)	d (nm)
$3s^3P^0 - 3p^3S$ $\overline{\lambda} = 358.55$ nm	5000.	.182E-01	-.529E-02
	10000.	.127E-01	-.380E-02
	20000.	.876E-02	-.277E-02
	30000.	.709E-02	-.234E-02
	40000.	.616E-02	-.209E-02
	50000.	.559E-02	-.195E-02
$3s^3P^0 - 3p^3D$ $\overline{\lambda} = 310.26$ nm	5000.	.149E-01	-.248E-02
	10000.	.104E-01	-.177E-02
	20000.	.719E-02	-.128E-02
	30000.	.582E-02	-.107E-02
	40000.	.506E-02	-.941E-03
	50000.	.459E-02	-.869E-03
$3s^3P^0 - 3p^3P$ $\overline{\lambda} = 286.21$ nm	5000.	.132E-01	-.210E-02
	10000.	.921E-02	-.149E-02
	20000.	.638E-02	-.107E-02
	30000.	.517E-02	-.885E-03
	40000.	.449E-02	-.775E-03
	50000.	.408E-02	-.705E-03

The illustration of the influence of the applied coupling scheme on Stark broadening parameter calculations are shown in Figs. 1 and 2. As one can see from the Figures, the differences are relatively small in comparison with the accuracy of the modified semiempirical method (±50) for the line width, but for the Stark shift, as e.g. for λ=313.55 nm (see Fig. 1), these differences may be important.

Similar results are obtained for Xe II lines (see Ref. 6), where the *jK* and the *LS* coupling approximation were assumed. Moreover, was noticed in this paper that Stark broadening parameters calculated within *jK* coupling scheme are in slightly better agreement with experimental data.

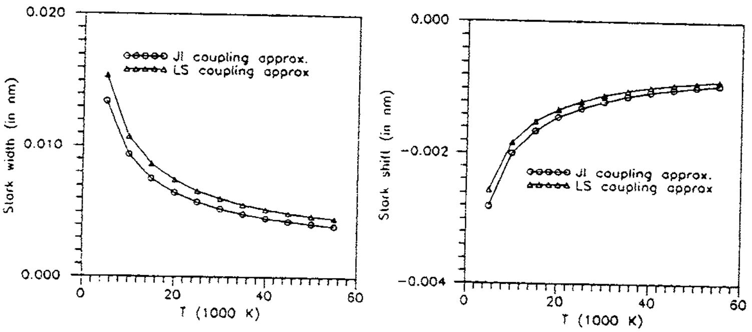

Fig. 2. Same as in Fig. 1, but for λ=313.55 nm ($3s^3P_0^0 - 3p^3D_1$ - notation within the LS coupling scheme; $3s[1/2]_0^0 - 3p[3/2]_1$ - notation within the $J\ell$ coupling scheme) was done.

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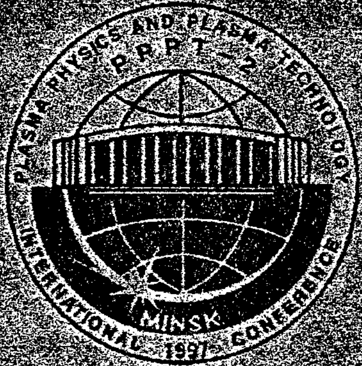

ФИЗИКА ПЛАЗМЫ И ПЛАЗМЕННЫЕ ТЕХНОЛОГИИ

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1997

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STARK BROADENING OF Si XI LINES

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1. Introduction

Stark broadening parameters for Si XI spectral lines are of interest for various aspects of investigation, modeling and diagnostic of laser produced plasmas, plasmas in fusion research and plasmas in subphotospheric layers, as well as for testing and developping of electron - impact broadening theory for shapes of multicharged ion lines and for the considerations of regularities and systematic trends particularly along isoelectronic sequences.

Within the semiclassical - perturbation formalism [1,2] we have calculated electron-, proton-, and He III-impact line widths and shifts for 4 Si XI multiplets. This contribution is the continuation of our efforts (see Refs. 3,4 and references therein) to provide to plasma physicists and astrophysicists Stark broadening parameters needed for the research of astrophysical and laboratory plasmas, as well as plasmas in various plasma devices in technology.

2. THEORY

A detailed description of the applied semiclassical perturbation approach used here, is given in Refs. 1,2. The original method has been improved and updated several times see Ref. 5 and references therein). According to Refs. 1,2 and 5, Stark full width (W) at the intensity half maximum (FWHM) and shift (d) of an isolated spectral line, may be expressed as

$$W = N\int vf(v)dv(\sum_{i'\neq i}\sigma_{ii'}(v) + \sum_{f'\neq f}\sigma_{ff'}(v) + \sigma_{el}) + W_R$$

$$d = N\int vf(v)dv\int_{R_3}^{R_D} 2\pi\rho d\rho\sin 2\phi_p \qquad (1)$$

where N is the electron density, $f(v)$ the Maxwellian velocity distribution function for electrons, ρ denotes the impact parameter of the incoming electron, i and f denote the initial and final atomic energy levels, and i', f' their corresponding perturber levels, while W_R gives the contribution of the Feshbach resonances.

The inelastic cross section $\sigma_{j,j'}(v)$ can be expressed by an integral over the impact parameter of the transition probability $P_{jj'}(\rho, v)$ as

$$\sum_{i' \neq i} \sigma_{jj'}(v) = \frac{1}{2}\pi R^2 + \int_{R_1}^{R_D} \sum_{j \neq j'} P_{jj'}(\rho, v), j = i, f \tag{2}$$

and the elastic cross section is given by

$$\sigma_{el} = 2\pi R_2^2 + \int_{R_2}^{R_D} 8\pi\rho d\rho \sin^2\delta$$

$$\delta = (\phi_p^2 + \phi_q^2)^{1/2}. \tag{3}$$

The phase shifts ϕ_p and ϕ_q due respectively to the polarisation potential (r^{-4}) and to the quadrupolar potential (r^{-3}), are given in Section 3 of Chapter 2 in Ref. 1. R_D is the Debye radius. All the cut-offs R_1, R_2, R_3 are described in Section 1 of Chapter 3 in Ref. 2. The formulae for the ion-impact widths and shifts are analogous.

3. Results and discussion

By using the semiclassical - perturbation formalism [3,4] we have calculated electron-, proton-, and He III-impact line widths and shifts for 4 Si XI multiplets. for perturber densities 10^{18}– 10^{23} cm^{-3} and temperatures T = 500,000 – 4,000,000 K. Detailed description of the theoretical formalism and of the obtained results, will be published elsewhere together with the complete report of the performed analysis (see Refs 6,7 and references therein). Atomic energy levels needed for calculations have been taken from Ref. 8. A sample of obtained results for perturber density of 10^{20}cm^{-3} is shown in Table 1.

One may conclude from Table 1 that for multicharged ion lines like Si XI lines, ion broadening remains a small corrections to the linewidth, but shifts due to proton impacts become dominant in comparison to electron - impact

Table 1. Electron-impact broadening parameters for Si XI, for perturber density of 10^{20} cm^{-3}. By dividing C by the corresponding full width at half maximum, we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

PERTURBER DENSITY = 1.E+20cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Si XI 2S 2P	500000.	0.285E-01	-0.427E-03	0.117E-03	-0.298E-03
303.3 A	750000.	0.234E-01	-0.388E-03	0.224E-03	-0.455E-03
C= 0.30E+23	1000000.	0.204E-01	-0.418E-03	0.347E-03	-0.602E-03
	2000000.	0.148E-01	-0.491E-03	0.834E-03	-0.104E-02
	3000000.	0.124E-01	-0.470E-03	0.124E-02	-0.133E-02
	5000000.	0.100E-01	-0.442E-03	0.179E-02	-0.169E-02
Si XI 2P 3S	500000.	0.179E-02	0.144E-03	0.117E-03	0.271E-03
52.3 A	750000.	0.153E-02	0.142E-03	0.216E-03	0.347E-03
C= 0.12E+21	1000000.	0.137E-02	0.141E-03	0.272E-03	0.409E-03
	2000000.	0.107E-02	0.141E-03	0.502E-03	0.529E-03
	3000000.	0.925E-03	0.135E-03	0.615E-03	0.592E-03
	5000000.	0.775E-03	0.118E-03	0.795E-03	0.677E-03
Si XI 2P 3D	500000.	0.192E-02	-0.871E-05	0.470E-04	-0.367E-04
49.2 A	750000.	0.159E-02	-0.890E-05	0.736E-04	-0.534E-04
C= 0.18E+21	1000000.	0.139E-02	-0.964E-05	0.965E-04	-0.665E-04
	2000000.	0.103E-02	-0.459E-05	0.155E-03	-0.986E-04
	3000000.	0.876E-03	-0.329E-05	0.196E-03	-0.120E-03
	5000000.	0.724E-03	-0.262E-05	0.241E-03	-0.139E-03
Si XI 2P 3D	500000.	0.163E-02	-0.149E-04	0.447E-04	-0.610E-04
46.4 A	750000.	0.135E-02	-0.134E-04	0.726E-04	-0.849E-04
C= 0.92E+20	1000000.	0.119E-02	-0.144E-04	0.101E-03	-0.105E-03
	2000000.	0.881E-03	-0.112E-04	0.173E-03	-0.148E-03
	3000000.	0.748E-03	-0.829E-05	0.229E-03	-0.173E-03
	5000000.	0.617E-03	-0.682E-05	0.293E-03	-0.197E-03

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THE PHYSICS OF IONIZED GASES

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STARK BROADENING OF Ga II AND Ga III STELLAR LINES

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The Stark broadening of selected Ga II and Ga III lines is evaluated by means of the modified semiempirical[1], Griem's semiempirical[2], approximate semiclassical method[3] and its modified version[1]. We consider lines which are observed in the spectra of peculiar A and B stars. A number of these stars show a strong overabundance of gallium[4,5] and the broadening effects should be taken into account when deriving the gallium abundance. Most of the stellar observed lines of Ga II and Ga III, including their resonance transitions, occur in the UV range and are observed by the IUE satellite (Fig. 1): a weak visible multiplet of Ga II at 4255-4262 Å appears for large abundances only.

In Fig. 1, together with the two stellar spectra observed by the IUE satelite, are presented synthetic spectra[5] also (with Stark broadening taken into account using present results). For the silicon star HD 25823 observed spectrum the best fit was obtained for an overabundance of gallium of 3000 times the solar value[5]. Consequently, log NGa/NH is estimated as 6.3±0.5 (solar value 2.8) Since this is an Ap-Si star and the hydrogen is ionized in large amount in the region of line formation, it is important to estimate the Stark broadening parameters of observed gallium lines.

Our results are presented in Table 1 and we can see that the modified semiempirical values are closer to the approximate semiclassical calculations than the values obtained using Griem's semiempirical formula. We can see also that the largest desagreement is on the high temperature limit (Ga II $4d\,^3D-4f\,^3F$). It is interesting to mention also, that simple estimates from Ref. 7 (Using only the ionization potential) give for the width of Ga II $4s^2\,^1S-4s\,^1P^o$ multiplet, W = 0.0135 Å at 20000 K which is identical with the modified semiempirical value.

From the comparison shown in Table 2 it appears that the Stark broadening of

Fig. 1 - Observed IUE high-resolution spectra of the stars HD 25823 (Ap-Si) and HD 17081 (normal) in the range 1406-1422 Å

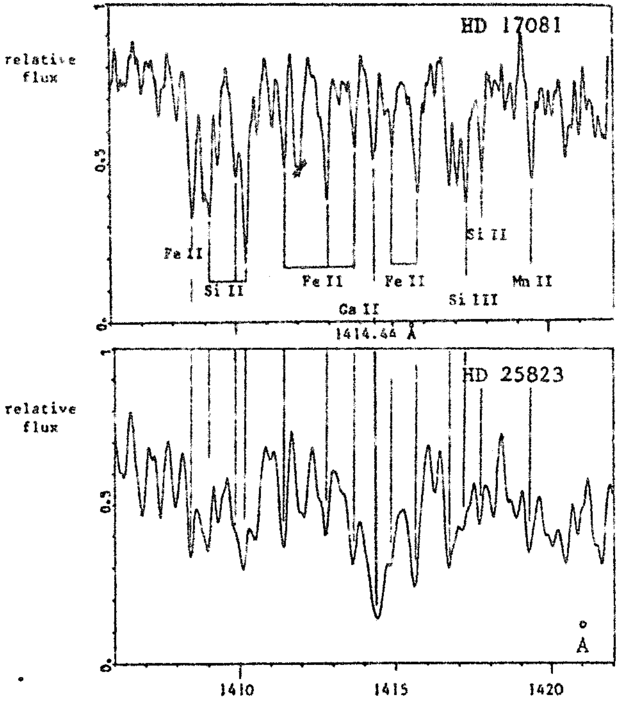

Fig. 2 - Calculated LTE synthetic spectra of a model atmosphere (13000 K, log g = 4) ;
a : with the solar abundances for all elements ;
b : with increased abundances of silicon (+1 dex) and gallium (+3.5 dex).

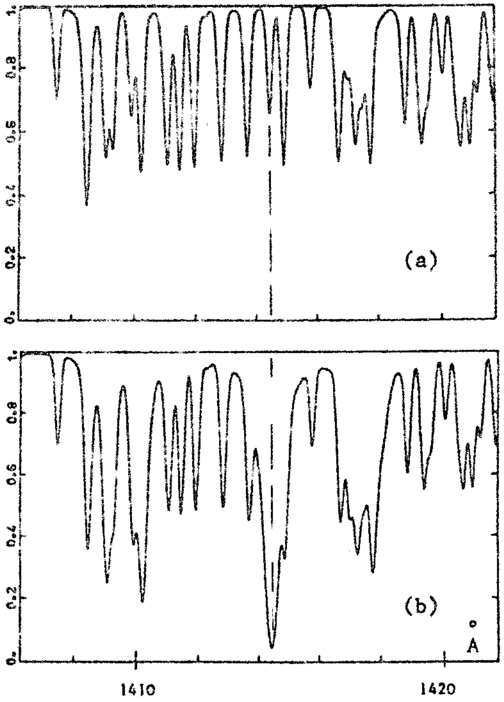

Table 1. Electron impact full half widths of stellar Ga II and Ga III lines at an electron density of 1×10^{17} cm^{-3} and T from 2500 to 40000 K. Transition and averaged wavelength for the multiplet (in Å) are also given. Under W_{SEM} and W_{SE} are given modified semiempirical[1] values and our calculations using Griem's semiempirical formula[2]. W_{GM} are approximate semiclassical results obtained from Eqs. (11-15) in Ref. 1 (with 1.4 instead of 5 - (4.5/Z) on the right-hand-side of Eq. 12 in Ref. 1), and W_G are results according to Griem's approximate semiclassical method[3]. The value for $3kT/2\Delta E$ represents the ratio of the termal electron energy at 10000 K to the energy difference to the nearest perturbing level.

Element/Transition	T(K)	W_{SEM}(Å)	W_{SE}(Å)	W_{GM}(Å)	W_G(Å)
Ga II $4s^2\ {}^1S-4p\,{}^1P^o$	2500	0.0382	0.0268	0.0436	0.0559
λ = 1414.4 Å	5000	0.0270	0.0189	0.0314	0.0401
$3kT/2\Delta E$=0.29	10000	0.0191	0.0134	0.0230	0.0292
	20000	0.0135	0.00953	0.0174	0.0220
	40000	0.00955	0.00676	0.0139	0.0173
Ga II $4d\,{}^3D-4f\,{}^3F^o$	2500	1.62		3.49	3.62
λ=4250 Å	5000	1.14		2.56	2.65
$3kT/2\Delta E$=65	10000	0.809		1.94	2.00
	20000	0.572		1.52	1.57
	40000	0.450		1.26	1.26
Ga III $4s\,{}^2S-4p\,{}^2P^o$	2500	0.0325	0.0229	0.0312	0.0436
λ= 1508 Å	5000	0.0230	0.0162	0.0223	0.0311
$3kT/2\Delta E$=0.16	10000	0.0163	0.0114	0.0162	0.0223
	20000	0.0115	0.00808	0.0120	0.0163
	40000	0.00814	0.00571	0.00942	0.0123

the UV resonance lines of Ga II and Ga III is comparable to the classical natural width (0.1 mÅ) commonly used for synthetic stellar spectra, and it is about 100 times smaller than the thermal Doppler broadening or the

Table 2. Comparison of line broadening effects for Ga II and Ga III lines for a typical stellar plasma with T=12000 K and $N_e=4\times10^{14}$ cm^{-3}.

		full halfwidth (mÅ)		
	multiplet	Stark	thermal Doppler	natural
UV	Ga II 1414 Å	0.072	5.6	0.066
	Ga III 1495-1534 Å	0.061	6.0	0.030
visible	Ga II 4255-4262 Å	3.0	17.	0.16

hyperfine splittings (roughly estimated to a few mÅ in the UV). In the visible range the relative effect of the Stark broadening is more important (20 times the natural width) but the Doppler broadening and the hyperfine structure still give the dominant contribution to the stellar absorption line profiles.

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SIMILARITIES OF STARK LINE WIDTHS WITHIN A GIVEN SPECTRUM AND IRREGULAR ENERGY LEVEL STRUCTURE

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UDC 539.186.24
Conference paper

SUMMARY

In order to find out if similarities among Stark broadening parameters within a given spectrum are apparent to such a degree that accurate interpolation of new data and critical evaluation of experimental results are possible, the exceptions to this rule in the available theoretical data have been analysed and reasons for such situations have been discussed. The reasons may be divided into two categories: (i) irregularities in the atomic energy levels structure and (ii) inadequacy of the used theoretical model.

1. INTRODUCTION

The investigation of the Stark broadening of atomic and ionic lines has attained great importance for the spectroscopy of astrophysical plasmas particularly for the evaluation of the physical conditions in the atmospherae of hot stars of types O and B and some white dwarfs as well as for the determination of the abundances of elements and for the estimation of the radiative transfer through the stellar plasma. When reliable Stark broadening data do not exist, knowledge about regularities and systematic trends offers an additional possibility for evaluation or critical estimation of needed data (see e.g. Konjević and Dimitrijević, 1981 and references therein).

2. RESULTS AND DISCUSSION

In order to find out if similarities among Stark broadening parameters within a supermultiplet and transition array are apparent to such a degree that interpolation of new data and critical evaluation of experimental results are possible, we made the analysis of the computed line widths for neutral and singly ionized atom lines (Benett and Griem, 1971; Jones et al., 1971) and examined all cases when large variations of Stark widths within a supermultiplet or transition array exist. The causes of all exceptions can be divided into two groups (Dimitrijević, 1982): (i) irregularities in the atomic energy

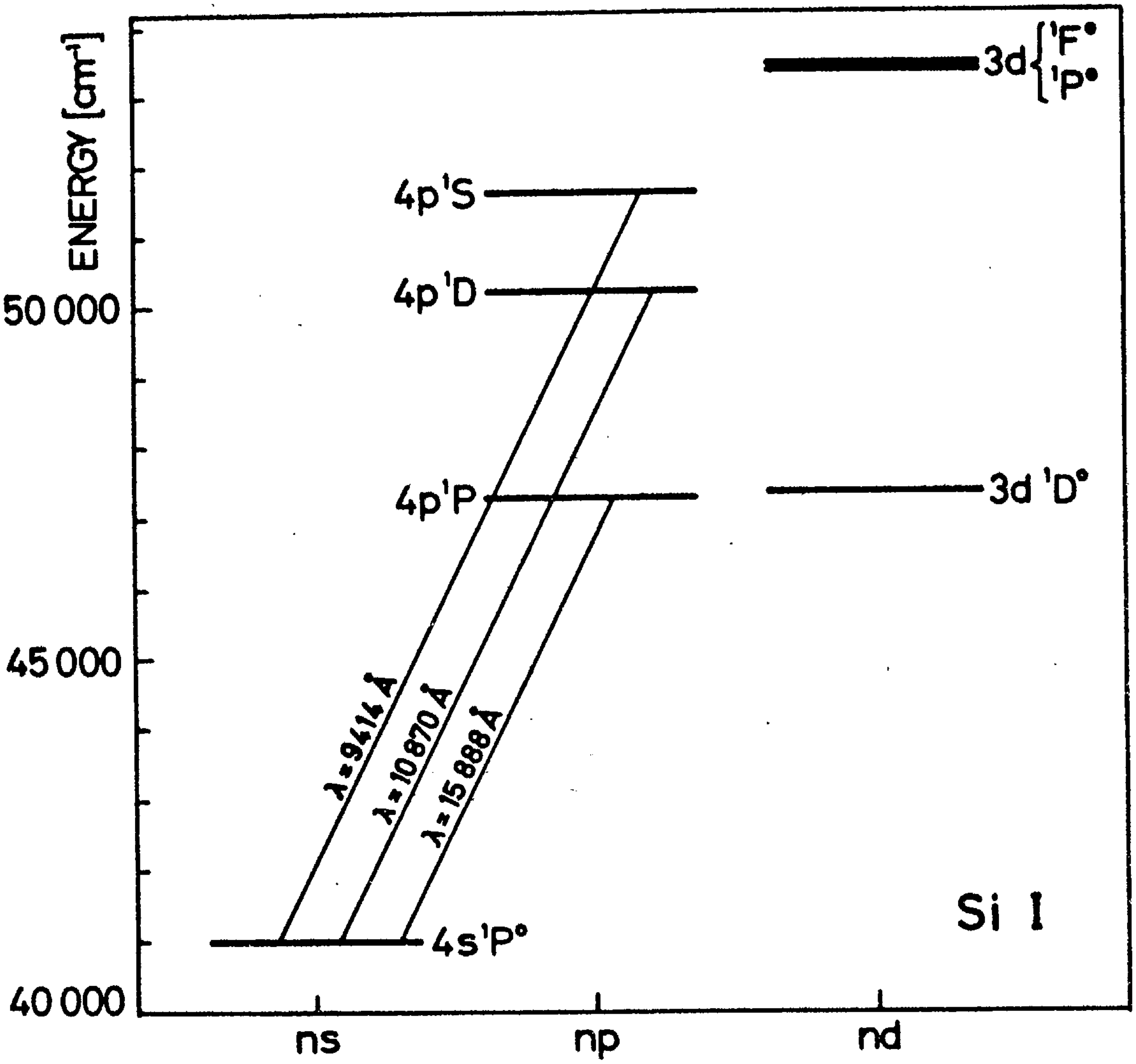

Figure 1. Partial energy level diagram for Si I showing the principal perturber levels for the 4s-4p transitions

levels structure and (ii) the failure of the one electron model, used in the calculations.

The largest differences between line widths within a supermultiplet or transition array occur when some principal perturbing energy levels are embeded right in the upper levels of the supermultiplet. One example of such irregular energy levels structure is the case of Si I 4s-4p singlets, shown on Fig.1. In this case, the $3d^1D^0$ perturbing level is so close to the $4p^1P$ level that the line widths for the $4s^2P^0$-$4p^1D$ and the $4s^1P^0$-$4p^1P$ transitions differ by factor eight at 5000 K. Also, we can see from the Fig. 2, where line widths within the supermultiplet vs. the temperature are presented, that the temperature trend for the $4s^1P^0$-$4p^1P$ width is completely different from the trends for other components of the supermultiplet.

In the case of the irregular energy levels structure, it is not easy to

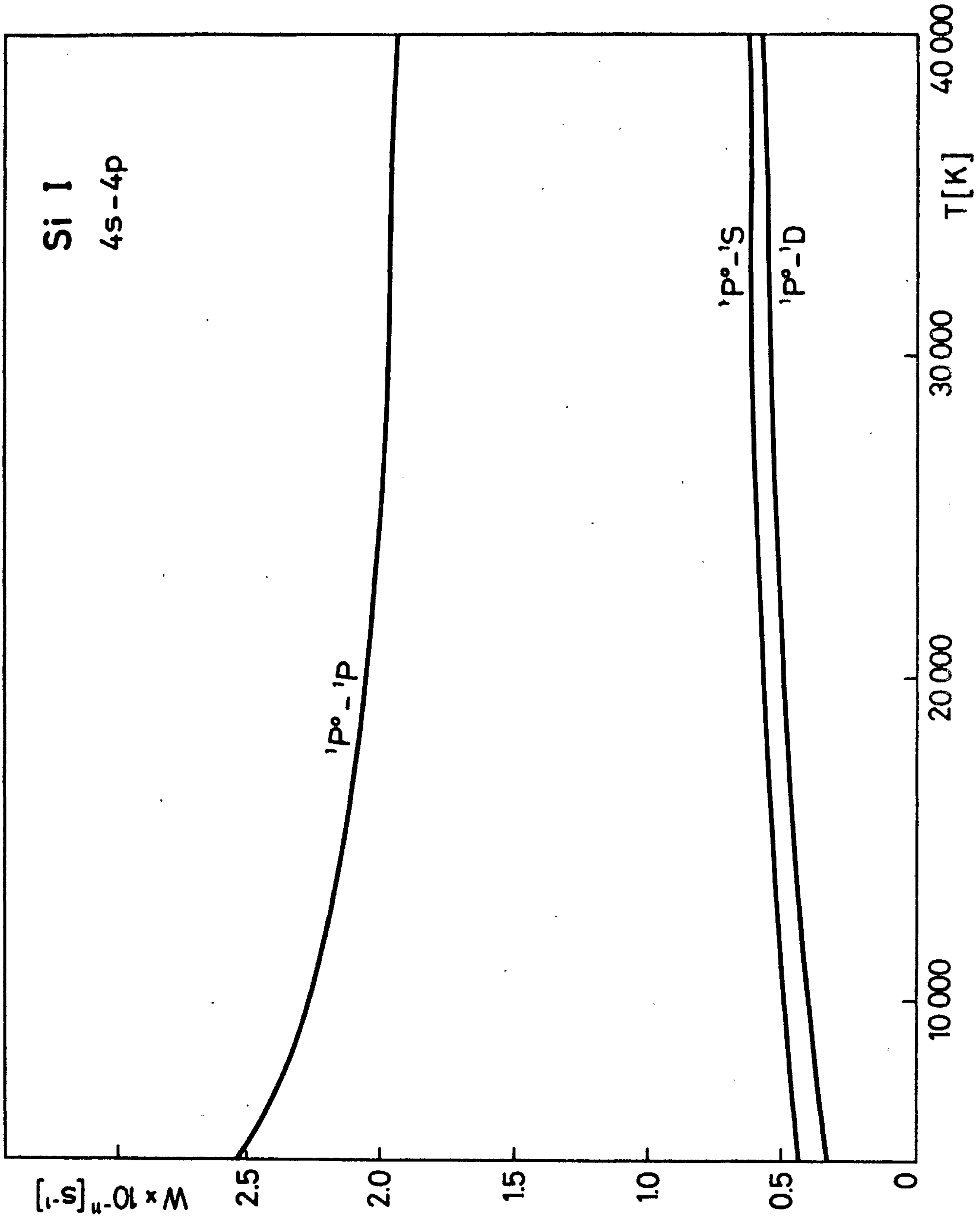

Figure 2. Theoretical results (Jones et al., 1971) for Si I Stark line widths within a supermultiplet vs. the electron temperature. The electron concentration N is 10^{16} cm^{-3}.

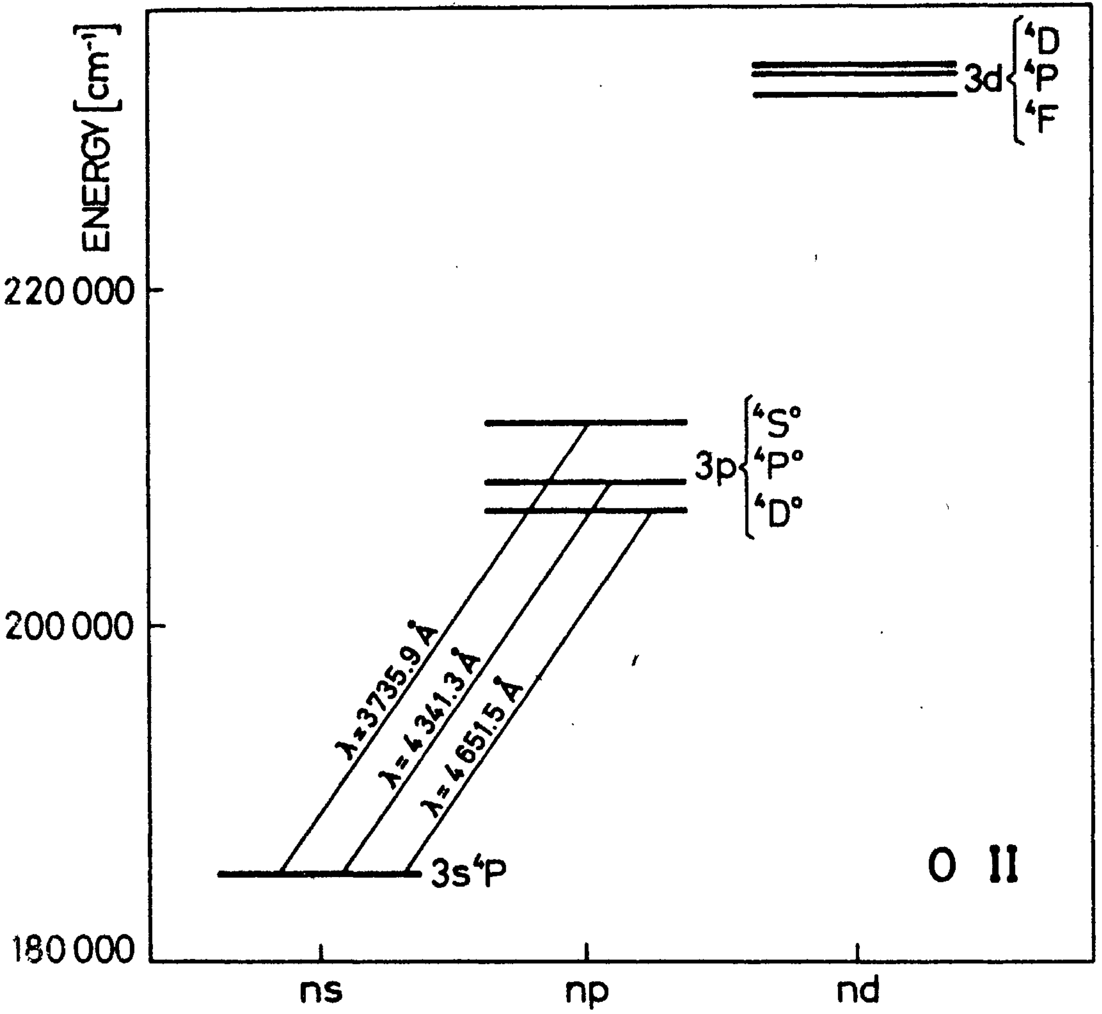

Figure 3. Partial energy level diagram for O II showing the principal perturber levels for the 3s-3p transitions.

predict the difference between various components within a supermultiplet or transition array using simple considerations. If energy differences to the perturbing levels are approximately the same, widths must be also approximately the same, but if large differences exist, other parameters must be taken into account. For the case of a close perturbing level it is also important how large is the contribution of this particular level to the total width. This depends on the relative magnitude of the corresponding matrix element and on the temperature. With the rise of the temperature, importance of the closest perturbing level diminishes, reducing also the difference of widths within a supermultiplet. This explains the temperature trends presented in Fig. 2, but in general case one must take into account that in Stark broadening formulae (Griem, 1974) enter the products between matrix elements (which are different for different members of the supermultiplet) and Stark broadening functions.

Transition (mult. No)	λ(Å)	$W\times10^{-11}$ (s^{-1})	ΔS/S	$W_{JBG}\times10^{-11}$ (s^{-1})	$(\Delta S/S)_{JBG}$	$W_m\times10^{-11}$ (s^{-1})
$3s^4P-3p^4D^o$ (1)	4652	2.80	-0.05	2.94	-0.03	1.99
$3s^4P-3p^4P^o$ (2)	4341	2.80	-0.05	2.38	-0.38	2.19
$3s^4P-3p^4S^o$ (3)	3736	3.00	-0.06	2.53	-0.49	2.75

Table 1. Comparison of present calculations (W) for Stark line widths (FWHM) of O II lines within a supermultiplet with other theoretical and experimental results. All values are for $N=10^{16}$ cm^{-3} and T=25900K. Theoretical results are taken from Jones et al. (1971) (W_{JBG}). Experimental results (W_m) are from Platiša et al. (1975). The completeness parameter ΔS/S is given for present calculations and for calculations of Jones et al. (1971) ($(\Delta S/S)_{JBG}$).

So, temperature trends may vary too.

The second cause of the differences of the theoretical line widths within a supermultiplet is often the unsuitability of the one electron model (only one energy level for each nl electrons) for line width of complex spectra. An example are the line widths for the O II 3s-3p quartets. We can see from the partial energy level diagram (Fig. 3) that line widths within this supermultiplet should be practicaly the same, but this is not the case in the Jones et al. (1971) calculations. Moreover, the completeness parameter differs considerably and this is an additional consequence of the failure of the used model for the considered case.

From the numerical results presented in Table 1, one can conclude that line widths within the considered multiplet are approximately equal, as expected, if we do not use the one electron approximation. Also, ΔS/S is now practicaly the same for all lines within the supermultiplet. As we can see, an indication for the inappropriate use of the one electron model is the great difference of ΔS/S within a supermultiplet. The completeness parameter should be the same within a supermultiplet, since the set of used energy levels is practicaly the same for each particular component.

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SLIČNOSTI ŠTARKOVSKIH ŠIRINA LINIJA U DATOM SPEKTRU I NEPRAVILNA STRUKTURA ENERGETSKIH NIVOA

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UDK 539.186.24
Članak sa konferencije

SAŽETAK

Da bi se ustanovilo da li su sličnosti izmedju parametara Starkovog širenja unutar datog spektra toliko izražene da je moguća interpolacija novih podataka i kritička procena eksperimentalnih rezultata, analizirani su izuzeci koji se javljaju u dostupnim teorijskim podacima i razmatrani su razlozi zbog kojih se oni javljaju. Razlozi se mogu podeliti u dve grupe: (i) nepravilnosti u strukturi energetskih nivoa u atomu i (ii) neadekvatna primena teorijskog modela.

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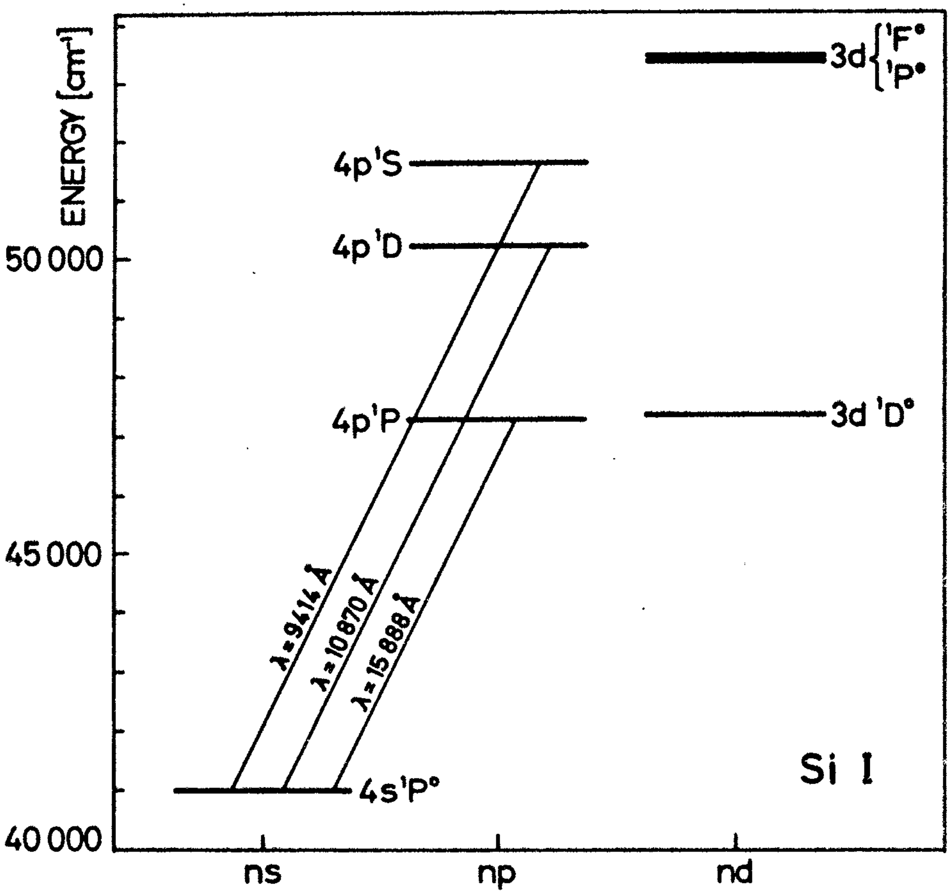

Figure 1. Partial energy level diagram for Si I showing the principal perturber levels for the 4s-4p transitions

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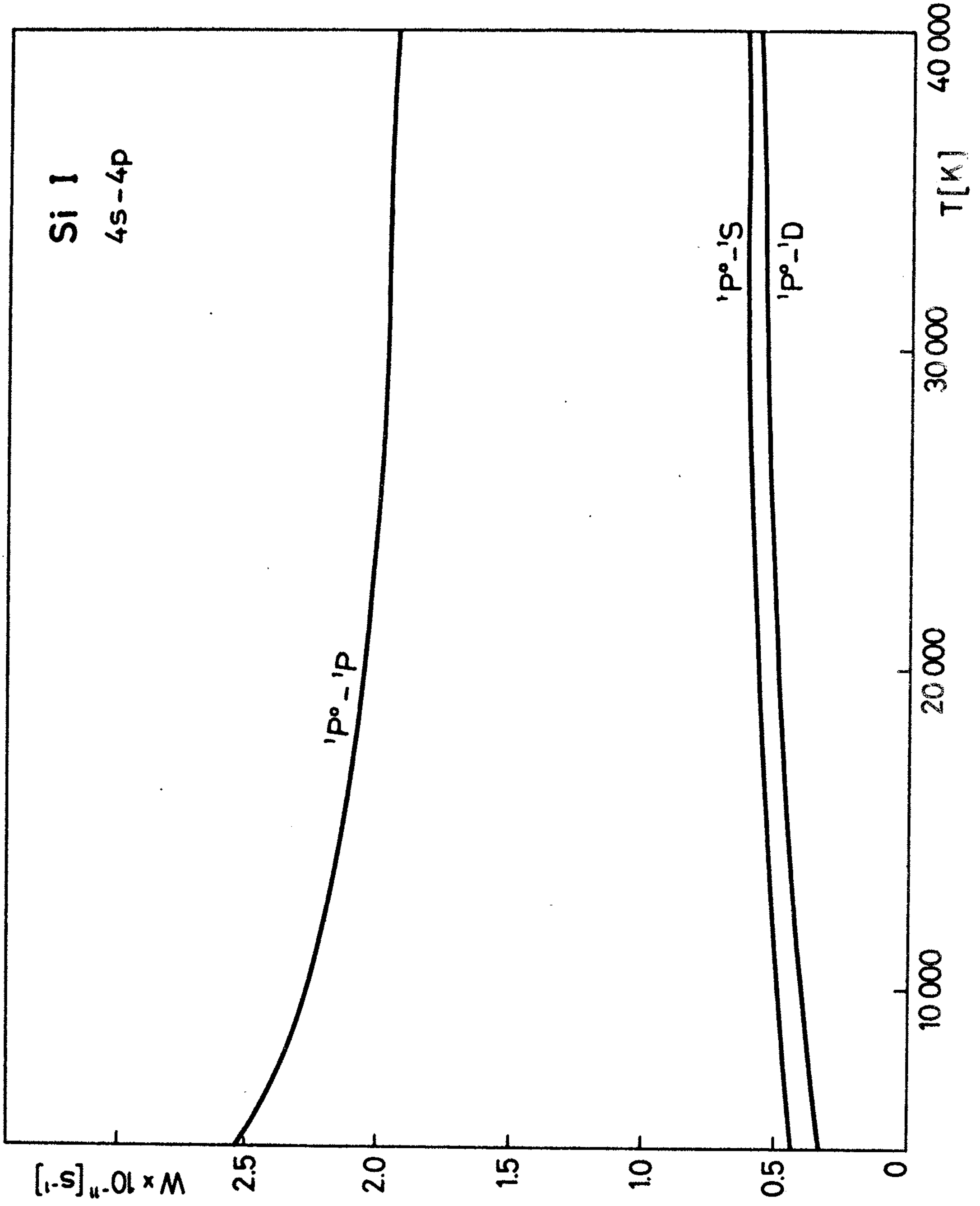

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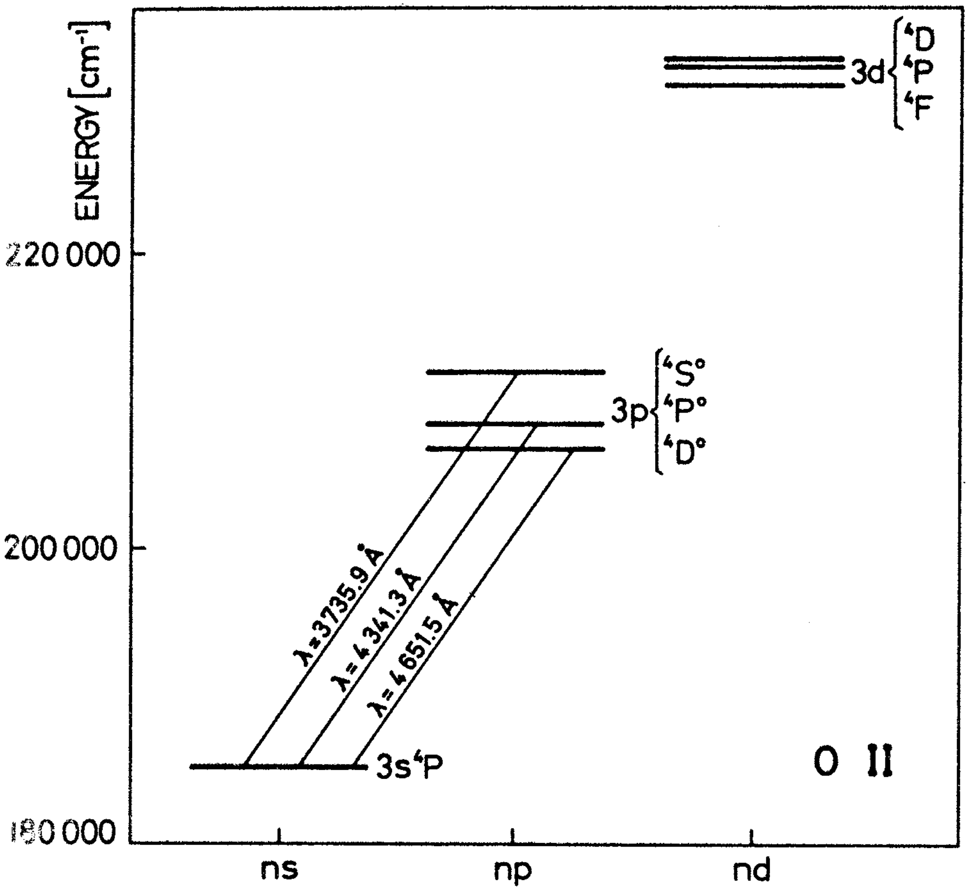

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$3s^4P-3p^4P^o$ (2)	4341	2.80	-0.05	2.38	-0.38	2.19
$3s^4P-3p^4S^o$ (3)	3736	3.00	-0.06	2.53	-0.49	2.75

Table 1. Comparison of present calculations (W) for Stark line widths (FWHM) of O II lines within a supermultiplet with other theoretical and experimental results. All values are for $N=10^{16}$ cm^{-3} and T=25900K. Theoretical results are taken from Jones et al. (1971) (W_{JBG}). Experimental results (W_m) are from Platiša et al. (1975). The completeness parameter $\Delta S/S$ is given for present calculations and for calculations of Jones et al. (1971) ($(\Delta S/S)_{JBG}$).

So, temperature trends may vary too.

The second cause of the differences of the theoretical line widths within a supermultiplet is often the unsuitability of the one electron model (only one energy level for each nl electrons) for line width of complex spectra. An example are the line widths for the O II 3s-3p quartets. We can see from the partial energy level diagram (Fig. 3) that line widths within this supermultiplet should be practicaly the same, but this is not the case in the Jones et al. (1971) calculations. Moreover, the completeness parameter differs considerably and this is an additional consequence of the failure of the used model for the considered case.

From the numerical results presented in Table 1, one can conclude that line widths within the considered multiplet are approximately equal, as expected, if we do not use the one electron approximation. Also, $\Delta S/S$ is now practicaly the same for all lines within the supermultiplet. As we can see, an indication for the inappropriate use of the one electron model is the great difference of $\Delta S/S$ within a supermultiplet. The completeness parameter should be the same within a supermultiplet, since the set of used energy levels is practicaly the same for each particular component.

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SLIČNOSTI ŠTARKOVSKIH ŠIRINA LINIJA U DATOM SPEKTRU I NEPRAVILNA STRUKTURA ENERGETSKIH NIVOA

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UDK 539.186.24
Članak sa konferencije

SAŽETAK

Da bi se ustanovilo da li su sličnosti izmedju parametara Starkovog širenja unutar datog spektra toliko izražene da je moguća interpolacija novih podataka i kritička procena eksperimentalnih rezultata, analizirani su izuzeci koji se javljaju u dostupnim teorijskim podacima i razmatrani su razlozi zbog kojih se oni javljaju. Razlozi se mogu podeliti u dve grupe: (i) nepravilnosti u strukturi energetskih nivoa u atomu i (ii) neadekvatna primena teorijskog modela.

I Workshop on Astrophysical spectroscopy

Orašac 26-30. August 2011.

PROGRAM AND ABSTRACTS

Edited by Milan S. Dimitrijević

Society of astronomers of Serbia and
Group for Astrophysical Spectroscopy, Belgrade 2011

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Zoran Simić, Astronomical Observatory, Belgrade
Marko Stalevski, Astronomical Observatory, Belgrade

Venue

The workshop will be held in Vila Aleksandar in Orašac (see web site: www.aleksandarwellness.rs).

Scientific rationale

Spectroscopy is a power tool for the analysis of radiation from different plasmas in astronomy, laboratory, fusion research and industry. The investigation of nature of the emitting ionized gas in galactic nuclei is one of important subjects in astrophysics today. Investigating the processes in the central parts of these objects, we can learn about the innermost parts of other 'normal' galaxies. Moreover, AGN are the most powerful sources, located at different cosmological time-scales, and their investigation is cosmologically important. Additionally, a part of emission from these objects (e.g. in the X-rays) has its origin very close to a massive black hole, and investigation of this emission can help us understand the physical processes in a strong gravitational field.

On the other side, a number of AGN are affected by gravitational lensing effect. Studies aimed at determining the influence of microlensing on spectra of lensed quasars (hereafter QSOs) ought to account for the complex structure of the QSO central emitting region. Since the sizes of the emitting regions are wavelength-dependent, microlensing by stars in a lens galaxy will lead to a wavelength-dependent magnification.

Efficace theoretical analyzis, synthezis and modelling of stellar spectra as well as the spectra from other plasma sources, depends on atomic data and their sources. In particular for the modeling of stellar atmospheres and opacity calculations a large number of atomic data is needed, since we do not know a priori the chemical composition of a stellar atmosphere. Consequently the development of databases with atomic data and astroinformatics is important for stellar spectroscopy.

Investigation of spectral line profiles is of significance for various research fields not only in astrophysics, where, for example, by analysis of stellar line profiles we can obtain effective temperature, chemical composition, surface gravity and other data on the investigated star, but also for a number of topics in physics and technology

The workshop is planned as an opportunity to consider above mentioned aspects of spectroscopic research on plenary sessions and than to work on the special mini-projects, which will result in common papers to be published in international astronomical journals) during the workshop.

PROGRAM

I Workshop on Astrophysical spectroscopy
Orašac 26-30. August 2011.

Friday 26.08.2011
11:00-11:30 Arrival and registration
11:30-12:00 Opening ceremony
12:00-13:00 Luka Popović: Spectroscopy as a tool for detection of super-massive binary black holes (Plenary IL)
13:00-13:30 Discussion on the common work and collaboration on problems in Spectroscopy of Active Galactic Nuclei

13:30-15:00 Lunch

15:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Saturday 27.08.2011
10:00-11:00 Andjelka Kovačević: Virtual Atomic and Molecular Data Center – VAMDC and AOB Node. Present status and perspectives (Plenary IL)
11:00-11:30 Milan S. Dimitrijević STARK-B Database and Virtual Atomic and Molecular Data Center – VAMDC (IL)
11:30-12:00 Darko Jevremović Serbian Virtual Observatory, Virtual Atomic and Molecular Data Center – VAMDC and Astroinformatics (IL)
12:00-12:30 Discussion on Virtual Atomic and Molecular Data Center – VAMDC and its future role for Astrophysical spectroscopy research (Moderators Luka Č. Popović and Milan S. Dimitrijević)

13:00-15:00 Lunch

15:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Sunday 28.08.2011

09:00-16:00 Excursion: Blagoveštenje Monastery, Risovača cave, Top of Mount Bukulja, Lunch in "Karadjordjev vajat"

17:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Monday 29.08.2011

11:00-12:00 Dragana Ilić: Results of the long-term spectral optical monitoring of the active galaxy 3c390.3 (Plenary IL)

12:00-12:30 Vladimir Srećković: Radiative ion-atom collisions in stellar atmospheres (IL)

12:30-13:00 Discussion on the common work and collaboration on problems of Astrophysical Plasma research

13:00-15:00 Lunch

15:00-18:00 Work in Sections 1-4 on Mini-projects

20:00 Conference dinner

Tuesday 30.08.2011

10:30- 12:00 Work in Sections 1-4 on Mini-projects

12:00 Closing Ceremony

13:00 Departure

SECTIONS (S) and MINI PROJECTS (MP)

(Participants which will be present are marked by boldface. Other will participate in work by Skype or e-mail)

S1 Spectroscopy of Active Galactic Nuclei (Coordinator Luka Č. Popović)

MP1.1 Optical monitoring of High Energy Emitting Galactic Nuclei
Participants: **G. La Mura,** D. Bindoni, S. Ciroi, V. Cracco, F. Di Mille, F. Gabrielli, **D. Ilić, L. Č. Popović, P. Rafanelli**, L. Vaona

MP1.2 Validity of the virialization approximation of the broad lines in AGNs
Participants: **L. Č. Popović, J. Kovačević, G. La Mura**

MP1.3 Radiative transfer modeling of AGN dusty tori
Participants: **Jacopo Fritz, Marko Stalevski**

MP1.4 Spectroscopy of gravitational lensing
Participants: **L. Č. Popović, S. Simić**

S2 Astrophysical plasmas (Coordinator Anatolij Mihajlov)

MP2.1 The influence of the radiative non-symmetric ion-atom collisions in the stellar atmospheres in UV and VUV regions
Participants: Lj.M. Ignjatović, **A.A.Mihajlov**, **V.A. Srećković, M.S. Dimitrijević, A. Metropoulos**

S3 Astroinformatics and spectroscopic research (Coordinator Andjelka Kovačević)

MP3.1 AOB (ASTRONOMICAL OBSERVATORY – BELGRADE) NODE OF THE VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Participants: **A. Kovaćevič, M. S. Dimitrijević, L. Č. Popović, Z. Simić, D. Jevremović, J. Aleksić**

S4 Spectral line profiles in stellar and laboratory plasmas (Coordinator Milan S. Dimitrijević)

MP4.1 On the electron impact broadening of doubly charged magnesium ion lines

Participants: **Zoran Simić, Andjelka Kovačević,** Nébil Ben Nessib, **Milan S. Dimitrijević**, Sylvie Sahal-Bréchot

MP4.2 On the Stark broadening of Cr II $3d^5$ - $3d^4 4p$ lines in stellar atmospheres

Participants: **Zoran Simić, Milan S. Dimitrijević, Andjelka Kovačević**, Sylvie Sahal-Bréchot

MP 4.3 Stark broadening of B IV

Participants: **Milan S. Dimitrijević, Magdalena Christova, Zoran Simić, Andjelka Kovačević, Jovan Aleksić,** Sylvie Sahal-Bréchot

MP4.4 Calculation of Stark broadening of several Ne I lines for astrophysical purposes

Participants: **M. Christova, M. S. Dimitrijevic, Z. Simic,** Sylvie Sahal-Bréchot

ABSTRACTS

INVITED LECTURES

SPECTROSCOPY AS A TOOL FOR DETECTION OF SUPERMASSIVE BINARY BLACK HOLES

Luka Č. Popović

Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia,

Spectroscopy can be very useful in detection of super-massive binary black holes. Here we will discuss the possible emission of gas around binary black hole, and consider the changes in spectra (narrow and broad spectral lines) due to the existence of such objects.

VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND AOB NODE. PRESENT STATUS AND PERSPECTIVES

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Darko Jevremović[2],
VAMDC Consortium (P. I. Marie-Lise Dubernet[4,5])
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Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project with the objective to create a secure, documented, flexible and interoperable e-science environment-based interface to existing atomic and molecular data, will be presented in this review. It will also provide a forum for dissemination and training of potential users.

Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela.

The VAMDC facilities will be first of all useful for Astronomy, Plasma science, Atmospheric Science Radiation science and Fusion community as well as Industries using technological plasmas and Lightning industry and will represent a powerful tool for a better and easier search for the needed atomic and molecular data and an efficace data mining.

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko

Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

In this lecture, we will consider VAMDC, a good example of the global collaborations and development of new facilities in e-science. Also, we will present AOB VAMDC Node and our plans for its further development.

STARK-B DATABASE AND VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC

Milan S. Dimitrijević[1,2], Sylvie Sahal-Bréchot[2]

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[2]Laboratoire d'Etude du Rayonnement et de la Matière en Astrophysique, Observatoire de Paris-Meudon, UMR CNRS 8112, Bâtiment 18, 5 Place Jules Janssen, F-92195 Meudon Cedex, France

The database STARK-B is a collaborative project between Laboratoire d’Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon and the Astronomical Observatory of Belgrade. For the moment STARK-B contains Stark line broadening parameters (widths and shifts) obtained within the impact approximation using the semiclassical perturbation approach and the impact approximation. It is devoted for modelling and spectroscopic diagnostics of stellar atmospheres and envelopes, as well as for laboratory plasmas, laser equipment, inertial fusion plasma and technological plasmas.

STARK-B database is a part of the core of European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC) e-infrastructure, one of the databases upon which it is based.

In this review, the STARK-B database will be presented as well as its connection with VAMDC.

SERBIAN VIRTUAL OBSERVATORY, VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND ASTROINFORMATICS

Darko Jevremović, Milan S. Dimitrijević, Luka Č. Popović, Jovan Aleksić

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SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) started as a project whose funding was approved through a grant TR13022 from Ministry of Science and Technological Development of Republic of Serbia, with duration of 33 months from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". After establishing SerVO and starting to digitize and archive photo plates and other astronomical data produced at Belgrade Astronomical Observatory, the aims are: i) To work on the development of SerVO and to join the EuroVO and IVOA; b) To develop SerVO data Center which will work on the digitizing, archiving and publishing in VO format photo-plates; c) To work on the development of tools for visualization of data; d) Make a regional node of Virtual Atomic and Molecular Data Center – VAMDC; e) Make a mirror site of STARK-B - Stark broadening data base containing as the first step Stark broadening parameters, obtained within the semiclassical perturbation approach and impact approximation, in VO compatible format; f) Make a mirror site for DSED - Darthmouth Stellar Evolution Database in the context of VO, and g) to put online electronic editions of serbian astronomical institutions.

In this review, the SerVO will be presented, and its history, aims and future plans, as well as its connections with European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), and its node on Belgrade Astronomical Observatory will be considered.

RESULTS OF THE LONG-TERM SPECTRAL OPTICAL MONITORING OF THE ACTIVE GALAXY3 C390.3

Dragana Ilić[1], Luka Č. Popović[2], Alla I. Shapovalova[3], Andjelka Kovačević[1],
Nikolai G. Burenkov[3], Vahram H. Chavushyan[3]
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The structure of the broad line region (BLR) in active galactic nuclei (AGN) is still not well known. The BLR is close to the central supermassive black hole and may hold basic information about the formation and fueling of AGN, as well as of the mass of the black hole in the center.

The AGN are highly variable objects. Especially their broad emission lines (BEL) are changing dramatically. The investigation of the BEL flux and profile variability in a long period is very useful for mapping the geometrical and dynamical structure of the BLR.

Here we present the result of the long-term spectral optical monitoring of a well know radio-loud AGN 3c390.3 that exhibit interesting double-peaked BEL profiles.

RADIATIVE ION-ATOM COLLISIONS IN STELLAR ATMOSPHERES

Vladimir A. Srećković[1], Anatolij A. Mihajlov[1], Ljubinko M. Ignjatović[1],
Milan S. Dimitrijević[2,3], Aristophanes Metropoulos[4]

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In this lecture, we will present results of our investigations of the influence of the processes of radiative charge exchange in symmetric and strongly non-symmetric ion-atom collisions on the opacity of solar and stellar atmospheres in UV and VUV regions. We considered several ion-atom systems ($H + H^+$, $He + He^+$, $He + H^+$ and $H + A^+$, where A = Li, Na etc.) and determined some characteristics, such as molecular potential curves and dipole matrix elements. They were used for the determination of coefficients of spectral absorption due to examined processes, together with the corresponding molecular photo-dissociation processes, in the atmosphere of the Sun and some DB white dwarfs. It was found that the influence of the considered processes should be taken into account for modeling of stellar plasma and analysis and synthesis of stellar spectra, since for example these processes generate rather wide and firm molecular absorption bands in the UV and VUV regions, which neglection will introduce errors in the interpretation of the observational data.

MINI PROJECTS

OPTICAL MONITORING OF HIGH ENERGY EMITTING GALACTIC NUCLEI

G. La Mura[1], D. Bindoni[1], S. Ciroi[1], V. Cracco[1], F. Di Mille[1], F. Gabrielli[1], D. Ilić[2],
L. Č. Popović[3], P. Rafanelli[1], L. Vaona[1]

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Approximately 20% of nearby galaxies show hints of energetic activity in their nuclear regions, through the presence of appreciable amounts of ionized gas. The source of activity is most often identified either with very young stellar populations, dominated by hot, massive stars, or with non-thermal processes occurring in the galactic nuclei.

Nowadays it has been realized that both possibilities take an important part in the evolution of galaxies. Indeed, there is increasingly strong observational evidence suggesting that nuclear activity and star formation are likely to be physically connected. However, to investigate whether there is a cause-effect relationship between these two phenomena, we have to investigate the properties of galaxies, the masses of which are in the critical range where starburst activity and AGN activity are more likely to be found (Rafanelli et al. 2011). In this project, we propose to operate the newly upgraded 1.22m telescope in Asiago to start a monitoring campaign of a list of such objects selected also on the basis of their high energy emission (X and gamma rays). Variable high energy emission, indeed, is considered as an effective track of AGN related processes. Our idea is to exploit the Asiago observatory as an optical facility to perform observations of objects, which are studied at high energies, too. Taking advantage from multiple frequency observations, it is our aim to improve the current understanding of nuclear activity in galaxies, investigating the dynamics of AGN central engines, as well as the properties of galaxies where ongoing star formation is probably overlapping with nuclear activity.

VALIDITY OF THE VIRIALIZATION APPROXIMATION OF THE BROAD LINES IN AGNS

Luka Č. Popović[1], Jelena Kovačević[1], Giovanni La Mura[2]

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The broad lines of AGNs are used to measure the mass of black hole, supposed to be in their center. Here we are going to check validity of virilization approximation of broad lines in AGNs. We measured widths of broad lines at 1/10, 1/5, 1/2 and 3/4 of the maximal intensity, and plot their ratios as a function of full width at maximal intensity. Using this plots we will be able to conclude how much is emitting gas gravitationally bounded.

RADIATIVE TRANSFER MODELING OF AGN DUSTY TORI

Jacopo Fritz[1], Marko Stalevski[2]

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[2]Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia

The inner regions of AGN (accretion disk and BLR) are surrounded by the toroidal structure composed of dust. This dusty torus absorbs the incoming radiation from the accretion disk and re-emits it in the infrared domain. Thus, to study the observed shape and features of spectral energy distributions (SED) in the infrared, radiative transfer modeling of dusty torus is necessary. During the workshop, the participants in this section will discuss further development and applications of the two-phase model of dusty torus presented in Stalevski et al. (2011). The topics to be covered include: investigation of different dust compositions, SED variations due to the changes in the inner torus structure, influence of size of clumps and their actual arrangement on SED.

SPECTROSCOPY OF GRAVITATIONAL LENSING

Luka Č. Popović[1], Saša Simić[2]

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The GAIA mission will be able to perform precise measurements of order of hundredth part of millisecond of arc. This will provide possibility to measure off-center changing of lensed quasars due to microlensing. Here we will investigate expected photocenter variability of lensed quasars due to microlensing. We will take into account the spectral bands in which the GAIA will work.

THE INFLUENCE OF THE RADIATIVE NON-SYMMETRIC ION-ATOM COLLISIONS IN STELLAR ATMOSPHERES, IN UV AND VUV REGIONS

Ljubinko M. Ignjatović[1], Anatolij A. Mihajlov[1], Vladimir A. Srećković[1],
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[4]Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation, Athens, Greece

The aim of this work is to draw attention to the processes of radiative charge exchange in strongly non-symmetric ion-atom collisions as factors of influence on the opacity of stellar atmospheres in UV and VUV regions. Therefore, for several ion-atom systems ($He + He^+$ and $H + A^+$, where A = Li, Na etc.) some characteristics have been determined, such as molecular potential curves and dipole matrix elements. Then, using these characteristics, calculations have been carried out to determine coefficients of spectral absorption due to these processes together with the corresponding molecular photo-dissociation processes, in the atmosphere of the Sun and some DB white dwarfs. The standard models of the considered atmospheres have been used in the calculations. It has been established that the examined processes generate rather wide and firm molecular absorption bands in the UV and VUV regions, which should be taken into account at interpretation of the data obtained from measurements.

AOB (ASTRONOMICAL OBSERVATORY – BELGRADE) NODE OF THE VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Zoran Simić[2],
Darko Jevremović[2], Jovan Aleksić[2]

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We will consider and discuss actual status and plans for the future development and activity of Serbian AOB (Astronomical Observatory – Belgrade) Node of Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project: Also, we will discuss activities, needed that AOB Node of VAMDC becomes a regional center for the connection of activities on atomic and molecular data, and an organizer of regional trainings for students and potential users, as well as a VAMDC Node for monitoring the needs of users in South Eastern Europe.

ON THE ELECTRON IMPACT BROADENING OF DOUBLY CHARGED MAGNESIUM ION LINES

Zoran Simić[1], Andjelka Kovačević[2], Nébil Ben Nessib[3], Milan S. Dimitrijević[1], Sylvie Sahal-Bréchot[4]

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Broadening of spectral lines by collisions with charged particles is of interest for a number of topics in astronomy and physics, like for astrophysical, laboratory, laser produced, fusion or technological plasma investigation, modelling and diagnostics. Magnesium is an element of particular astrophysical importance due to its high cosmic abundance. For example Solar abundance of magnesium is the largest after H, He, O, C, Ne and N. Moreover, carbon burning in stellar interiors of some massive stars produces oxygen-neon-magnesium cores.

Within the semiclassical perturbation approach, using the impact approximation, we will consider ab intio, using the Cowan code for the needed energies and oscillator strengths, Stark broadening parameters for several Mg III lines. In addition to electron-impact full halfwidths and shifts, Stark broadening parameters due to proton-, and doubly charged helium ion-impacts
will be investigated as well, in order to provide Stark broadening data for the important charged perturbers in stellar atmospheres.

The obtained results will be compared with the available theoretical results.

ON THE STARK BROADENING OF Cr II $3d^5$ - $3d^4 4p$ LINES IN STELLAR ATMOSPHERES

Zoran Simić[1], Milan S. Dimitrijević[1], Andjelka Kovačević[2],
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Chromium lines are interesting due to their presence in stellar atmospheres. They have been identified in stellar spectra, as for example o Peg, 7 Sex, and φ Aqu, in which spectrum Caliskan and Adelman identified 28 Cr II spectral lines and noted overabundace with value log Cr/H = -5.85±0.27. Consequently, data on the Stark broadening of single ionized chromium spectral lines are of interest not only for laboratory but also for astrophysical plasma research. Of particular interest are resonance lines, since they are often present in stellar spectra.

We analyze here, the importance of Stark broadening effect for Cr II $3d^5$ - $3d^4 4p$ transitions in stellar atmospheres.

STARK BROADENING OF B IV

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The light elements lithium, breryllium and boron are of particular interest since they undergo nuclear reactions at relatively low temperatures reached in the solar-type stars outside the core, so that their circulation and destruction can produce observable changes in abundances, providing informations on stellar structure and mixing by convection. Boron lines are observed in Sun and stars. For example Proffitt and Quigley (2001) studied B III 2065.8 Å resonance line in 44 early B type stars determining the abundance of boron. In this work we will determine within the impact approximation, by using the semiclassical perturbation theory, Stark broadening parameters for B IV lines, needed for stellar plasma research and modelling, as well as for a number of research topics in plasma physics. The obtained data will be used to investigate the influence of Stark broadening of spectral lines in stellar atmospheres.

CALCULATION OF STARK BROADENING OF SEVERAL Ne I LINES FOR ASTROPHYSICAL PURPOSES

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Neon lines are present in stellar spectra and due to its high cosmical abundance, as well as to the fact that carbon burning in stellar interiors produces oxygen-neon-magnesium cores, this element is particularly interesting for astrophysical plasma research, including the Stark broadening of lines in its spectrum. For example the Solar abundance of neon is the largest after H, He, O and C. Here, we will investigate Stark broadening of neon spectral lines within the series $2p^5 3p\ ^2[5/2]_3 – 2p^5 nd\ ^2[7/2]°_4$. The new Stark broadening parameters will be determined using the semiclassical perturbation approach and the impact approximation. The obtained results will be used for the investigations of regularities and systematic trends of Stark broadening parameters within a spectral series and for the investigation of the influence of Stark broadening in stellar spectra.

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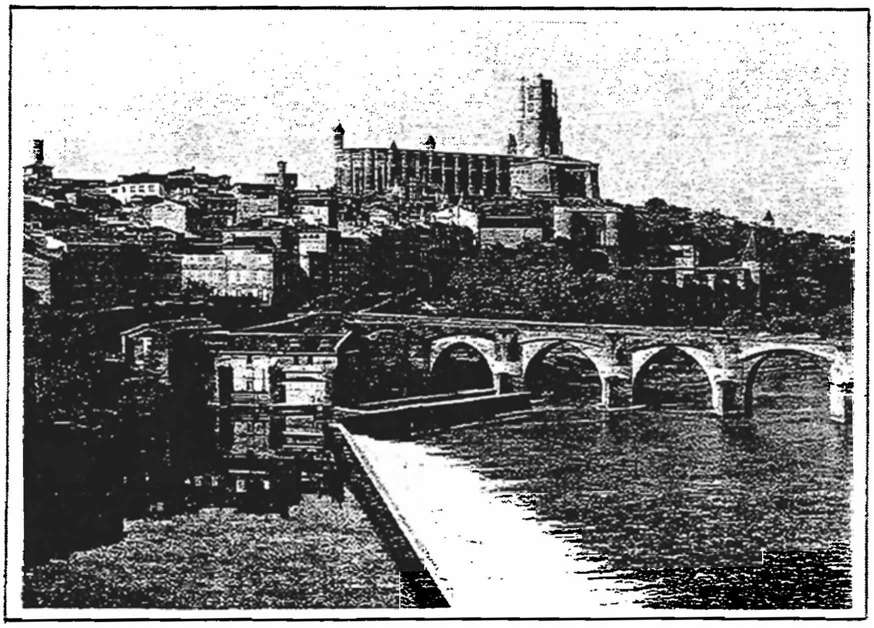

Journées de Spectroscopie Moléculaire

1er Colloque

Albi 18 et 19 Juillet 1994

D.I.A.M.

3ème Colloque sur la Dynamique des Ions, Atomes et Molécules

Albi 19 au 21 Juillet 1994

STARK BROADENING OF As II SPECTRAL LINES

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Astronomical Observatory, Volgina 7, 11050 Belgrade, Yugoslavia

Introduction

Stark broadening data are of importance for astrophysical and laboratory plasma research. Here, we present Stark broadening calculations for six As II spectral lines within the modified semiempirical approach [1,2] for electron density of $10^{23}\mathrm{m}^{-3}$ as a function of temperature.

Results and discussion

The needed atomic data for As II have been taken from refs. [3,4,5]. The departure from *LS* coupling has been taken into account representing the corresponding states as a mixiture of singlet and triplet states [6,7]. The obtained results for Stark full width (FWHM) and shift for six As II spectral lines are presented in Table 1.

Table 1. Stark width (FWHM) and shift of As II spectral lines at an electron density of $10^{23}\mathrm{m}^{-3}$ as a function of temperature.

TRANSITION	T (K)	WIDTH (nm)	SHIFT (nm)	TRANSITION	WIDTH (nm)	SHIFT (nm)
$5s^3P_0^0 - 5p^3D_1$ $\lambda = 549.77$ nm	5000.	.822E-01	-.851E-02	$5s^3P_0^0 - 5p^3P_1$ $\lambda = 488.85$ nm	.111	.102E-03
	10000.	.575E-01	-.462E-02		.905E-01	.325E-02
	20000.	.412E-01	-.117E-03		.874E-01	.534E-02
	50000.	.315E-01	.275E-02		.683E-01	.462E-02
$5s^3P_0^0 - 5p^3S_1$ $\lambda = 447.12$ nm	5000.	.121	-.160E-01	$5s^3P_1^0 - 5p^3D_1$ $\lambda = 562.06$ nm	.108	-.250E-01
	10000.	.848E-01	-.103E-01		.751E-01	-.178E-01
	20000.	.613E-01	-.466E-02		.537E-01	-.130E-01
	50000.	.471E-01	.149E-02		.406E-01	-.107E-01
$5s^3P_1^0 - 5p^3D_2$ $\lambda = 555.81$ nm	5000.	.117	-.264E-01	$5s^1P_1^0 - 5p^1P_1$ $\lambda = 799.05$ nm	.255	-.102
	10000.	.814E-01	-.189E-01		.181	-.748E-01
	20000.	.582E-01	-.138E-01		.136	-.565E-01
	50000.	.441E-01	-.113E-01		.114	-.518E-01

The obtained Stark width for As II $\lambda = 799.05$ nm ($5s^1P_1^0 - 5p^1P_1$) spectral line is in satisfactory agreement with simple estimate by Djeniže *et al.* [8] based on the regularities and systematic trends.

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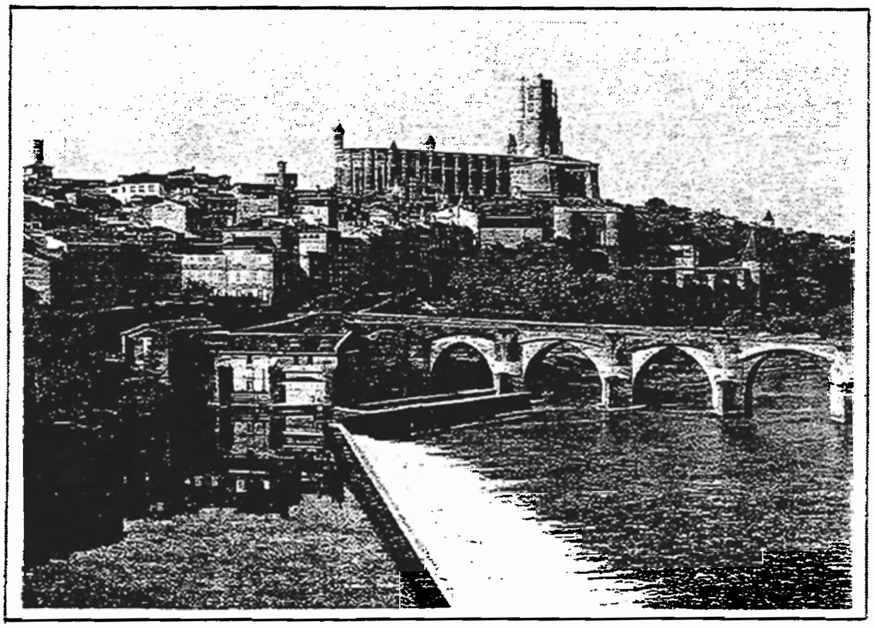

Journées de Spectroscopie Moléculaire

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STARK BROADENING OF Ne VIII LINES

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[2] Observatoire de Paris-Meudon, 92190 Meudon, France

By using the semiclassical-perturbation formalism we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 20 Ne VIII multiplets, in order to continue our research of multiply charged ion line Stark broadening parameters, with the special emphasis on the lithium isoelectronic sequence. A summary of the formalism is given in Dimitrijević et al. (1991). Here, we present and discuss the obtained results, and also the comparison with experimental data (Glenzer et al. 1992) and other theoretical calculations (Glenzer et al. 1992; Seaton 1988) and estimattes (Purić et al 1988).

Table 1. Experimental (Wm) Stark widths (FWHM) in Å for Ne VIII $3s^2S$-$3p^2P^o$, λ = 2820.7 Å line, compared with the theory. WDSB - the present semi-classical calculations; WS - Seaton (1988); WG - Glenzer et al (1992) by using Eq. (526) in Griem (1974); WDK - Glenzer et al (1992) by using the modified semiempirical approach (Dimitrijević & Konjević (1980); WH - calculated by Hey (cited as private communication in Glenzer et al 1992) by using the quasiclassical Gaunt factor approach (Hey & Breger 1982)

Transition	kT[eV]	Ne[10^{18}cm^{-3}]	Wm[Å]	Wm/WDSB	Wm/WS	Wm/WG	Wm/WDK	Wm/WH
Ne VIII	29.7	2.8	1.2	1.91	3.29	2.22	2.55	1.83
$3s^2S$-$3p^2P^o$								
2820.7 Å	42.5	3.2	1.2	1.67	3.47	2.07	2.45	1.77

In Table 1, our results for Ne VIII $3s^2S$ - $3p^2P^o$ 2820.7 Å line are compared with the available experimental data (Glenzer et al. 1992) and with calculations of Glenzer et al. (1992) by using different approximate methods. The best agreement of our results is with the results (Glenzer et al 1992) obtained by using the quasiclassical Gaunt factor approximation of Hey & Breger (1982). All calculations give lower values than the experimental ones.

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MILUTIN MILANKOVIC AND THE ASTRONOMICAL SOLUTION OF THE ICE-AGES PROBLEM

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The scientific work of Milutin Milankovic (Dalj, May 28, 1879 - Belgrade, December 12, 1958), one of the most distinguished Serbian scientists, which name have a crater on the far side of the Moon, a crater on Mars and asteroid 1605 Milankovic is analyzed. He went down in the history of science as the man who explained the phenomenon of the Ice Ages by slow changes of the Earth insolation in consequence of changes of the Earth’s axis inclination and of those of the parameters of the Earth’s motion round the Sun. The most important Milankovic’s work is "Kanon der Erdbestrahlung und seine Anwendung auf das Eiszaitenproblem" (The Cannon of the Earth’s Insolation and its Application to the Ice Ages Problem). It is his capital scientific work, a monograph, comprising results of his researches previously published in 28 research works. In this monograph these results are assembled in one whole, together with new analyses and supplements, including numerous examples and applications of his theory. In this capital work Milankovic presents mathematical theory of Earth’s climate (applicable also to other planets), explaining the origin of the Ice Ages and exposing his theory of the Earth’s poles motion. He did important contributions to the Celestial Mechanics and the History of Astronomy and was a great popularizator of science. At the Ortodox Church Council in 1923 in Istanbul, he submitted the proposal concerning the reform of the calendar, providing for a more exact calendar than the Gregorian one.

SISSA ISAS

IAU Colloquium 138

Peculiar versus Normal Phenomena in A-type and Related Stars

Abstracts of invited and contributed papers
May 26, 1992

SISSA Ref. 91/92/A

Strada Costiera 11 - 34014 Trieste - ITALY

STARK BROADENING OF Pt II LINES IN CHEMICALLY PECULIAR STARS

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The interest for a very extensive list of line broadening data is particulary stimulated by spectroscopy from space. In such a manner an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, stimulating the spectral-line-shape research.

Lines of Pt II have been discovered in HgMn stars by Dworetsky (1969). An analysis of few strong Pt II transitions which are also observed in IUE spectra of stars had shown (Dworetsky et al., 1984) "that Pt is, like Hg, among the most overabundant elements in the atmospheres of HgMn stars, with enhancements of the order of 10^4 to 10^5 over the solar system abundances".Dworetsky et al. (1984) selected also the four Pt II lines which might be used for astrophysical applications. Moreover, they determined the corresponding astrophysical gf values. The aim of this contribution is to investigate Stark broadening of these Pt II lines and to provide the corresponding Stark widths.

ON STARK BROADENING OF HEVY ELEMENT LINES IN A-TYPE STAR SPECTRA: Bi II LINES

M. S. Dimitrijević and L. Č. Popović

Astronomical Observatory, Volgina 7, 11050 Beograd, Serbia, Yugoslavia

1. INTRODUCTION

Stark broadening data are of the great importance for astrophysical and laboratory plasma spectroscopy. For evaluation and modelling of stellar atmospheric physical properties and abundace determinations, Stark broadening data for a large number of transitions in many atoms are needed.

Seven strong absorption lines due to ionized bismuth have been found in the Hg - Mn star HR 7775 in high - resolution spectra obtained with IUE (Jacobs and Dworetsky, 1982). Performed analysis shows existence of the overabundance of Bi of 10^6 while Jacobs and Dworetsky (1982) have not detected Bi II in the spectra of several other Hg - Mn stars. Since the plasma conditions in HR 7775 star atmosphere are $T_{eff} = 11000$ K, $\log g = 4.0$ (Jacobs and Dworetsky, 1982), it is of interest to provide the corresponding Stark broadening parameters which might be of significance for abundance investigation, determination of astrophysical gf values and other sellar plasma research. Besides of an astrophysical importance, Stark broadening of Bi II lines is interesting and for labaratory plasma research and was investigated experimentally by Miller and Bengston (1980) and Purić et *al.*, (1985). Moreover the case of Bi II lines is interesting from the theoretical point of view since this is an example of depature from LS - coupling which gives the opportuity to study influence of such effect on Stark broadening parametars.

STARK-BROADENING OF Hg II LINES IN STELLAR ATMOSPHERES

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1. INTRODUCTION

Stark broadening data for some Hg II lines are of importance for investigation of stellar spectra. For example the $6s^2\ ^2D_{5/2}$ - $6p\,^2P^o_{3/2}$ 3983.9 Å Hg II line is a strong and characteristic feature in the spectrum of HgMn Bp stars, most of the Mn stars, and in some magnetic Ap stars.[1-4] This line is used, e.g., for the Hg abundance determination in the atmosphere of φ Her.[5] The significance of the resonance $6s\,^2S$ - $6p\,^2P^o$ 1942 Å Hg II line for the Hg stellar abundance determination has been pointed out in Ref. 1. The mentioned Hg II multiplets, as well as the $6p\,^2P^o$ - $6d\,^2D$ and $6p\,^2P^o$- $7s\,^2S$ transitions, have been observed in the α And spectrum.[6,7]

STARK BROADENING PARAMETERS FOR Be II SPECTRAL LINES

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[‡]Observatoire de Paris-Meudon, 92190 Meudon, France

1. INTRODUCTION

Besides the interest for plasma spectroscopy (Platiša et al, 1971; Purić and Konjević, 1972; Hadžiomerspahić et al, 1973; Sanchez et al, 1973) the Be II Stark broadening parameters are important to astrophysicists since the surface content (abundance) of light elements, especially Li and Be, involves problems correlated with nucleogenesis, mixing between the atmosphera and the interior, stellar structure and evolution (Boesgaard, 1988). Moreover, Be II profiles are of importance for opacity calculations as well (Seaton, 1983).

ION-ATOM COLLISIONS AND ELECTRON RECOMBINATION IN ASTROPHYSICAL HYDROGEN PLASMA

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Besides the interaction between diatomic molecular ions and colliding atom - atomic ion complexes with radiation in plasma, it is obviously actual and the problem of their interaction with free electrons. Recently has been presented and applied to hydrogen case a quasiclassical method for the calculation of total and partial recombination rate coefficients for the following processes (Mihajlov et al. 1992):

$$A_2^+ + e \longrightarrow A + A^*(n) \tag{1a}$$

$$A + A^+ + e \longrightarrow \begin{cases} A + A^*(n) \\ A^*(n) + A \end{cases} . \tag{1b}$$

where A denotes a neutral atom in ground state, A^+ and A_2^+ atomic and molecular ions in ground states, $A^*(n)$ atom excited to the level with the principal quantum number n, and e denotes free electron. Processes (1a) and (1b) are important recombination channels in weakly ionised stellar plasmas, for temperatures $T \lesssim 10000$ K

In this contribution we present an approximate method, derived from previous one for the case $n \gg 1$. In the case of hydrogen, this method agrees within several percents with previous one for $n \gtrsim 10$ and converges very quckly. The method is based on tables with results of more sophysticated calculations for a particular $n \gg 1$ ($n = 10$ in the present case), which are a starting point for a simple interpolation to higher n cases.

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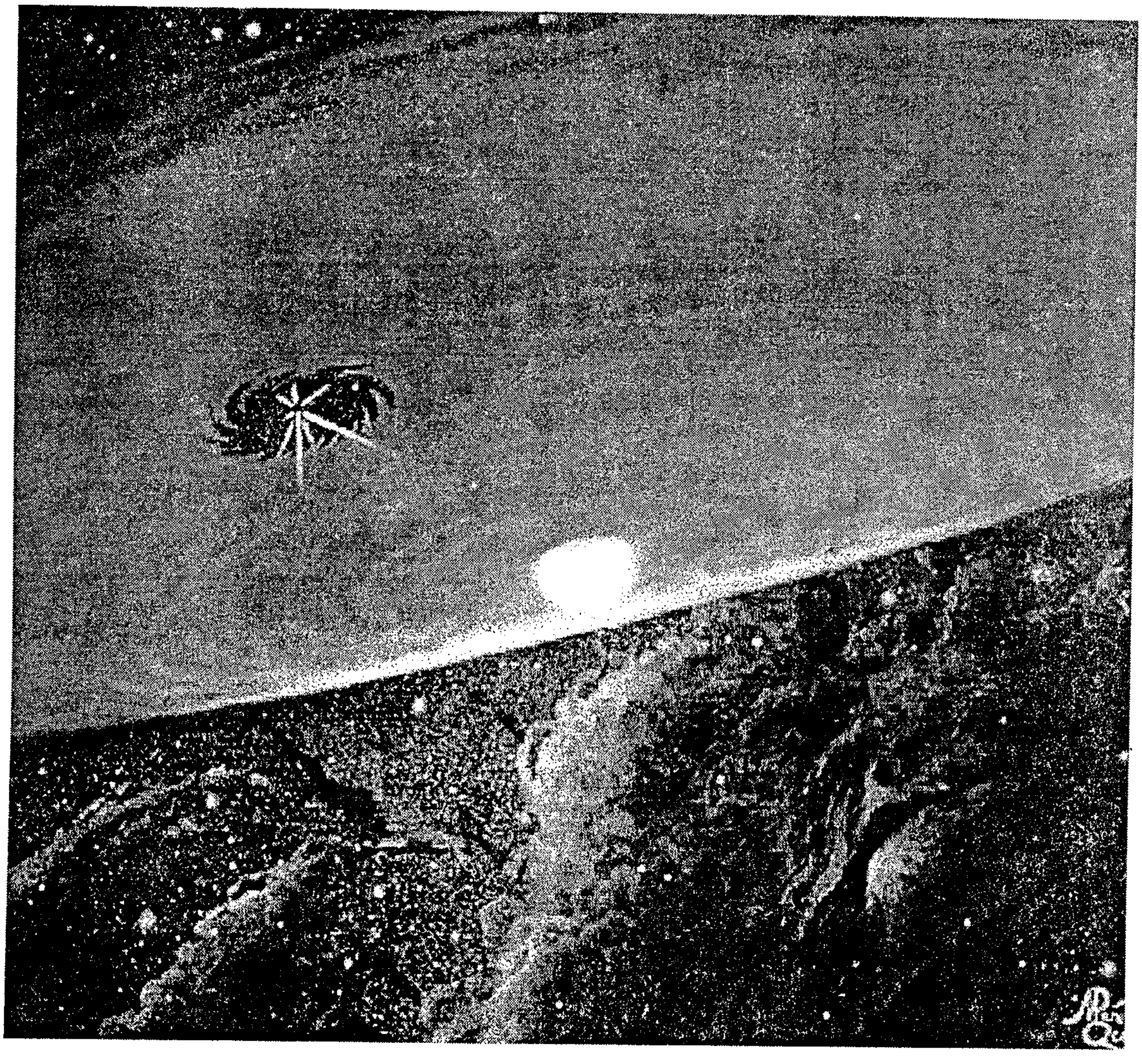
The Be Phenomenon in Early-Type Stars

28th June — 2nd July 1999
Alicante (Spain)



ABSTRACTS

A PROJECT FOR LARGE-SCALE STARK BROADENING DATA PRODUCTION OF INTEREST FOR Be STARS

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Abstract

In early-type stars like B and A stars and white dwarfs, Stark broadening is the main pressure broadening mechanism, and the corresponding Stark broadening parameters are of interest for a number of investigations related to Be stars. One may mention as examples calculation of stellar opacities, stellar atmospheres modelling and investigations, abundance determinations, interpretation and modelling of stellar spectra and investigation and modeling of subphotospheric layers.

In a series of papers we have performed large scale calculations of Stark broadening parameters for a number of spectral lines of various emitters (see e.g. [?], [?]. In order to complete as much as possible Stark broadening data needed for astrophysical and laboratory plasma research and stellar opacities calculations we are making a continuous effort to provide Stark broadening data for a large set of atoms and ions. Our calculations are performed within the semiclassical - perturbation formalism, for transitions when a sufficiently complete set of reliable atomic data exist and the good accuracy of obtained results is expected.

Extensive calculations have been performed, up to now [?] for a number of radiators, and consequently, Stark broadening parameters for 79 He I, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 12 B III, 23 Al III, 10 Sc III, 27 Be III, 32 Y III, 20 In III, 2 Tl III, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 2 Pb IV, 19 O V, 30 N V, 25 C V, 51 P V, 34 S V, 26 V V, 30 O VI, 21 S VI, 2 F VI, 14 O VII, 10 F VII, 10 Cl VII, 20 Ne VIII, 4 K VIII, 4 Ca IX, 30 K IX, 8 Na IX, 57 Na X, 48 Ca X, 4 Sc X, 7 Al XI, 4 Si XI, 18 Mg XI, 4 Ti XI, 10 Sc XI, 9 Si XII, 27 Ti XII, 61 Si XIII and 33 V XIII multiplets become available.

Data for particular lines of F I, B II, C III, N IV, Ar II, Ga II, Ga III, Cl I, Br I, I I, Cu I, Hg II, N III, F V and S IV also exist.

We hope that the obtained set of reliable Stark broadening parameters will be of interest for the various investigations concerning Be stars.

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Joint Discussion 4
UV astronomy: stars from birth to death

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Abstract. The scientific program is presented as well a the abstracts of the contributions. An extended account is published in *"The Ultraviolet Universe: stars from birth to death"* (Ed. Gómez de Castro) published by the Editorial Complutense de Madrid (UCM), that can be accessed by electronic format through the website of the Network for UV Astronomy (www.ucm.es/info/nuva).

There are five telescopes currently in orbit that have a UV capability of some description. At the moment, only *FUSE* provides any medium- to high-resolution spectroscopic capability. *GALEX*, the *XMM* UV-Optical Telescope (UVOT) and the *Swift*. UVOT mainly delivers broad-band imaging, but with some low-resolution spectroscopy using grisms. The primary UV spectroscopic capability of *HST* was lost when the Space Telescope Imaging Spectrograph failed in 2004, but UV imaging is still available with the *HST*-WFPC2 and *HST*-ACS instruments.

With the expected limited lifetime of sl FUSE, UV spectroscopy will be effectively unavailable in the short-term future. Even if a servicing mission of *HST* does go ahead, to install COS and repair STIS, the availability of high-resolution spectroscopy well into the next decade will not have been addressed. Therefore, it is important to develop new missions to complement and follow on from the legacy of *FUSE* and *HST*, as well as the smaller imaging/low resolution spectroscopy facilities. This contribution presents an outline of the UV projects, some of which are already approved for flight, while others are still at the proposal/study stage of their development.

This contribution outlines the main results from Joint Discussion 04 held during the IAU General Assembly in Prague, August 2006, concerning the rationale behind the needs of the astronomical community, in particular the stellar astrophysics community, for new UV instrumentation. Recent results from UV observations were presented and future science goals were laid out. These goals will lay the framework for future mission planning.

Keywords. ultraviolet-general, ultraviolet-solar system, ultraviolet-stars, ultraviolet-ISM, space vehicles-instruments

1. Preface

This joint discussion was organized to provide a forum during the IAU General Assembly where the accomplishments of UV astrophysics could be highlighted and a new road map for the future discussed.

The UV range is of prime interest for astrophysics since the resonance lines of the most abundant atoms and ions at temperatures between 3 000 K and 300 000 K, together with the electronic transitions of the most abundant molecules (H_2, CO, OH, CS, S_2, CO_2^+, C_2, O_2, O_3, ...) are at UV wavelengths. After enjoying more than 30 years of continuous access to this range, the astronomical community has been facing uncertain times and provision during the decade 2010–2020 remains so. Coordination is required to define the science goals for the future and the resulting requirements for future UV instrumentation.

chosen. From archival, high-dispersion *IUE* spectra, different lines that originate in the HTR region were considered, namely the resonance lines of Si IV, C IV and Al III, and He II 1640. Equivalent widths (corrected for photospheric contribution), optical depths, atom columns and expansion velocities were measured. From this observational data several correlations between different observables were obtained. These correlations permit us to discuss the geometry, density distribution and heat input of the lines formation regions (LFRs). The major results can be summarised as follows:

(*a*) The circumstellar material contributes to the resonance lines of Si IV, C IV, Al III and to the He II 1640 at all inclination angles.

(*b*) In Si IV, C IV and Al III the equivalent widths have a tendency to increase in objects with high rotational velocities.

(*c*) Si IV and C IV equivalent widths are also correlated to the kinetic energy of the expansion velocity. This means that dissipation of mechanical energy is one of the heating mechanisms.

(*d*) On the basis of the expansion velocities and the line profiles, we establish a sequence for the LFRs: The LFR of He II is at the base of the wind and the closest to the central star. The LFRs of Si IV and C IV are inmersed in the stellar wind. The LFR of Al III is an interface between the HTR and the cool envelope.

The analysis followed in this work is completely model-independent. Consequently, these results could be useful to decide which are the facts that are to be considered when modelling Be-type stars.

9.4. *High resolution spectroscopy of halo stars in groundbased UV*

Valentina Klochkova, Gang Zhao, S. Ermakov, and Vladimir Panchuk: For the first time an atlas of high-spectral resolution ($R = 60\,000$) CCD-spectra in the low studied wavelength range 3 500 - 5 000 Å is presented for four stars with values of metallicity $-3.0 < [\mathrm{Fe/H}] < -0.6$, temperatures $4750 < T_{\mathrm{e}} < 5900$ K, and surface gravity $1.6 < \log g < 5.0$. Based on these spectral data we determined model atmosphere parameters and calculated abundances of 29 chemical elements or their ions.

9.5. *Hyper ionization phenomena in the C IV, N IV, and N V regions of 20 Oe-type stars, including HD 93521*

Antonios Antoniou, E. Danezis, Evaggelia Lyratzi, D. Nikolaidis, L.C. Popovic, and M.S. Dimitrijevic: As it is already known, the spectra of many Oe- and Be-type stars present Discrete Absorption Components (DACs) which, due to their profiles' width as well as the values of the radial velocities, create a complicated profile of the main spectral lines. In this poster paper we detect the presence of this phenomenon (DACs or SACs) in the C IV resonance lines, the N IV spectral line, and the N V resonance lines of 20 Oe-type stars of different spectral subtypes. In particular we discuss these lines in the spectrum of the star HD 93521 which is a relatively bright, very rapidly rotating O9.5V star.

Method: In our study we apply the method proposed by Danezis *et al.* on the *IUE* spectra of 20 Oe-type stars, including the star HD 93521 observed with *IUE* from 1979 until 1995, and we examine the time variations of the physical parameters, stated below, as a function of the spectral subtype.

Results: As a first result we detect that the C IV resonance lines, the N IV spectral line, and the N V resonance lines each consist of one to five Satellite Absorption Components (SACs or DACs). With the above method we calculate the values of the apparent rotational and radial velocities, the Gaussian standard deviation of the random motions of the ions, the random velocities of these motions, as well as the optical depth, the column

density, the Full Width at Half Maximum (FWHM), the absorbed and the emitted energy of the independent regions of matter which produce the main and the satellites components of the studied spectral lines.
Discussion: We point out that the new and important aspect of our study is the values' calculation of the above parameters, their time scale variations and their variations as a function of spectral subtype,using the DACs or SACs theory. Our results are a successful test of this theory and of Danezis *et al.* proposed method. This study is a part of a Ph.D. Thesis.

9.6. *Study of Hα regions in 120 Be-type stars, and the complex structure of the Si* IV *1393.755, 1402.77 Å regions of 68 Be-type stars*

Evaggelia Lyratzi, E. Danezis, Antonios Antoniou, D. Nikolaidis, L.C. Popovic, and M.S. Dimitrijevic: As it is already known, the spectra of many Oe- and Be-type stars present Discrete Absorption Components (DACs) which, due to their profiles' width as well as the values of the radial velocities, create a complicated profile of the main spectral lines. In this poster paper we detect the presence of this phenomenon (DACs or SACs) in the shape of Hα line in the spectra of 120 Be-type stars, and in the Si IV resonance lines in the spectra of 68 Be-type stars of all the spectral subtypes and luminosity classes.
Method: In our study we apply the method proposed by Danezis *et al.* on the stellar spectrographs of 120 Be-type stars which were taken by Fehrenbach and Andrillat (resolution 5,5 and 27 Å with the telescope of 152 cm in the Observatory of Haute Provence), and on the spectra of 68 Be stars observed with *IUE*, and we examine the variations of the physical parameters, stated below, as a function of spectral subtype and luminosity class.
Results: We find that in the Be-type stellar atmospheres, there are two regions that can produce the Hα Satellite Absorption Components (SACs or DACs). The first one lies in the chromosphere and the second one in the cool extended envelope. With the above method we calculate: (*a*) For the chromospheric absorption components we calculated the optical depth as well as the rotational and radial velocities of the independent regions of matter which produce the main and the satellites components. *b*) For the emission and absorption components which are created in the cool extended envelope we calculated the FWHM, the optical depth and the radial velocities of the independent regions of matter which produce the main and the satellites components.
We find that the absorption atmospherical regions where the Si IV resonance lines originated may be formed of one to five independent density layers of matter which rotate with different velocities, producing one to five Satellite Absorption Components (SACs or DACs). With the above method we calculate the values of the apparent rotational and radial velocities, as well as the optical depth of the independent regions of matter which produce the main and the satellites components of the studied spectral lines.
Discussion: We point out that the new and important aspect of our study is the values' calculation of the above parameters and their variations as a function of spectral subtype and luminosity class, using the DACs or SACs theory. Our results are a successful test of this theory and of Danezis *et al.* (2003, 2005) proposed method. This study is a part of a Ph.D. Thesis.

9.7. *A new approach for DACs and SACs phenomena in the atmospheres of hot emission-line stars*

D. Nikolaidis, E. Danezis, Evaggelia Lyratzi, L.C. Popovic, M.S. Dimitrijevic, Antonios Antoniou, and E. Theodossiou: As it is already known, the spectra of

many Oe- and Be-type stars present Discrete Absorption Components (DACs) which, due to their profiles' width as well as the values of the radial velocities, create a complicated profile of the main spectral lines. This fact is interpreted by the existence of two or more independent layers of matter, in the region where the spectral lines are formed. Such a structure is responsible for the formation of a series of satellite components (DACs or SACs) for each spectral line (Bates & Halliwell, 1986, Danezis *et al.* 2003, 2005).
Method: In this paper we present a mathematical model reproducing the complex profile of the spectral lines of Oe-type and Be-type stars that present DACs or SACs. This model presupposes that the regions, where these spectral lines are formed, are not continuous but consist of a number of independent absorbing or emitting density layers of matter and an external general absorption region. In this model we assume that the line broadening is due to the random motion of the ions and the rotation of the density regions that produce the spectral line and its satellite components. With this method we can calculate the values of the apparent rotational and radial velocities, the Gaussian standard deviation of the random motions of the ions, the random velocities of these motions, as well as the optical depth, the Full Width at Half Maximum (FWHM), the absorbed and the emitted energy and finally the column density of the independent regions of matter which produce the main and the satellites components of the studied spectral lines.
Results: In order to check the above spectral line function, we calculated the rotational velocity of He I 4387.928 Å absorption line in the spectra of five Be-type stars, using two methods, the classical Fourier analysis and our model. The values of the rotational velocities, calculated with Fourier analysis, are the same with the values calculated with our method.
Discussion: We point out that the new and important aspect of this method is the values' calculation of the above parameters using the DACs or SACs theory.

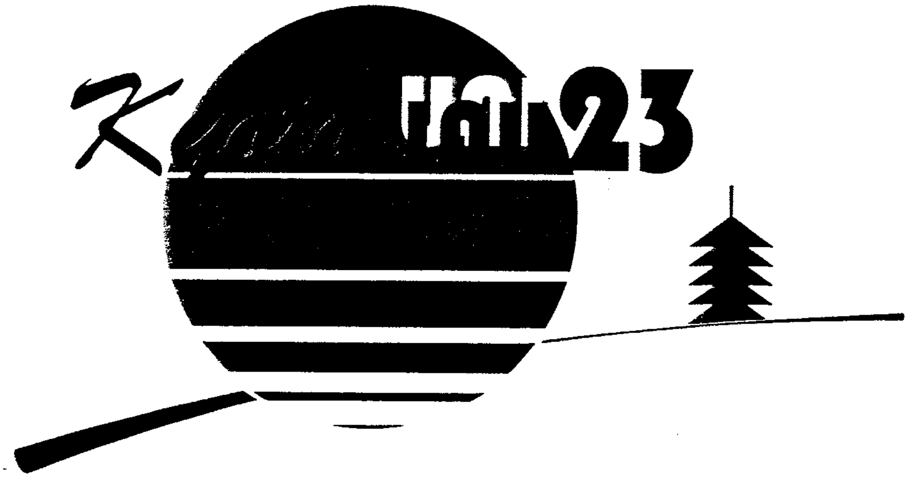
9.8. *Eta Carinae: what we have learned from HST-*STIS *in the UV*

Theodore R. Gull: The Luminous Blue Variable η Carinae is revealing many answers to its mysteries by high spatial resolution in the visible and the ultraviolet. Studies with the *HST*-STIS from 1998.0 to 2004.3 show major changes in the stellar and nebular spectra that track with the 2024-day period first noted by A. Damineli in the visible and followed by M. Corcoran via *RXTE* x-ray monitoring. We will show examples of the stellar and nebular spectra indicating changes in the central source, likely a massive binary system and indicating the response of the nebular ejecta, which is the $> 12\,M_\odot$ Homunculus, the $0.5\,M_\odot$ Little Homunculus, both bipolar structures, with intervening skirts. Within the interior skirt are located the Weigelt blobs, B, C and D, plus the Strontium Filament, all of which respond to the strong UV emission originating from the hot, less massive companion. Narrow-line absorption systems correlate with the Homunculus and Little Homunculus and are seen in hundreds of metal lines. For the Homunculus, the metal energy level populations correspond to 760 K, but the OH, CH, NH and CH+ to 60 K, while nearly a thousand H_2 lines are visible during the broad maximum. The Little Homunculus has a kinetic temperature of $\sim$6400 K during the broad maximum, but drops to 5000 K during the short minimum. Much is being learned about the N-rich, C,O-poor chemistry of this ejecta from a massive star in the late stages of CNO-processing. Recent GRB spectra show similar hot metal absorption gases likely being the ejecta from progenitor stars. Were they Wolf-Rayet stars?

9.9. *High resolution echelle spectrograph NES for visible and groundbased UV regions*

Vladimir E. Panchuk, Valentina G. Klochkova, I.D. Najdenov, and Maxim V. Yushkin: We present the high-resolution echelle spectrograph NES of the 6 m telescope.

Abstract Book



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The spectrum of β Coronae Borealis in the Lithium region

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The last results of spectral observations of the binary CP star $\beta CrB(HD137909, HR5747, F0p)$ in the Li (6708A) region are presented.

The observations were carried out at the Crimean Observatory from 1993 to 1995 with the coude spectrograph with a CCD detector.

Several factors which can affect the behavior of the Li blend were considered: 1) the binarity of βCrB; 2) the isotopic shift Li^6/Li^7; 3) the stellar rotation; 4)the Li feature is a blend of some unidentified lines of overabundant heavy elements(Ce, Gd, Sm).

We have determined the Li abundance by the spectral synthesis method for different physical conditions at the surface of the star (T_{eff}, $logg$) and different isotopic ratios for the resonance doublet of lithium.

The main result of this paper are: the variability of the profile of the lithium blend with the phase of rotation of the star; a good correlation between $FWHM$ of the Li blend and Hs magnetic field variations.

JD16-017P

INTERNATIONAL PROJECT- LITHIUM IN MAGNETIC CP STARS

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The lithium attracts exceptional attention among the many chemical anomalies of Ap stars. The reason is the large variety of atmospheric abundances of this element. There are very few data on Li abundance in Ap stars. Cool magnetic Ap stars are very interesting objects, which present unusual characteristics: strong overabundances of Sr, Cr, Eu and Rare Earths; strong and roughly dipolar magnetic fields; vertical stratification of the Ca abundance; inhomogeneous distribution of the elements on their surface; even rapid, non-radial oscillations on time scales of minutes. In these stars an effect of the magnetic field on the observable line complicates the interpretation of the observations.

We propose to observe Li I 6708 at different, well-distributed rotational phases in four cool Ap stars with high spectral resolution and S/N ratio of >100. The main purpose is to examine the abundance behaviour of Li at each phase, taking into account the effects of chemical peculiarity, magnetic field, and rotation. The observations will be made at ESO,LA PALMA,CRIMEAN,ROZEN.

JD16-018P

THE ELECTRON IMPACT PARAMETERS IN THE ATMOSPHERES OF CP STARS: Ga III LINES

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Spectral lines of doubly ionized gallium are observed in spectra of pecullar A- and B-stars. In atmospheres of hot stars (A and B) the contribution of electron-emitter collisions is the main pressure broadening mechanism. Knowledge of the Stark broadening parameters for astrophysically interesting spectral lines is needed for the stellar atmosphere investigations and modeling. Here we present Stark widths for 12 transitions of Ga III calculated by using the modified semiempirical approach.

JD16-020P

Detection Feasibility of Magnetic Fields and Hg Abundances in HgMn Stars

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We analyzed two Fe sc II lines at 6147.7 Åand 6149.2 Åobserved in 14 HgMn stars with the purpose to examine the feasibility of detecting magnetic fields in HgMn stars based on Mathys' empirical relation between the strengths of the Fe sc II lines and magnetic fields (Mathys 1990, A&A 232, 151). Takada-Hidai & Jugaku (1992, PASP 104, 106) found that the Fe sc II 6149 Åis strongly blended with the Hg II 6149.5 Åline in the typical HgMn star μ Lep. To investigate the blending effect of the Hg II line, we measured the strengths of Fe sc II lines in the sample stars with the Hg abundances of $4 < \log Hg < 7$ and obtained Hg abundaces from the blending Hg sc II lines. Most of the resulting Hg abundances were found to agree with the previously determined values within about 0.6 dex. We also found, from a comparison between the strengths of Fe sc II lines with Hg abundances, that the blending effect of the Hg sc II line seems to be negligible for the Hg abundances of about < 5 dex, and therefore magnetic fields may possibly be detected with Mathys' empirical relation in case of HgMn stars with such Hg abundances as < 5 dex.

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STARK BROADENING OF STELLAR Pt II LINES

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Lines of Pt II have been discovered in Hg Mn stars by Dworetsky (1969). The analysis of a few strong Pt II transitions, which are also observed in IUE spectra of stars, has shown (Dworetsky et al., 1984) "that Pt is, like Hg, among the most overabundant elements in the atmospheres of Hg Mn stars, with enhancements of the order of 10^4 to 10^5 over the solar system abundances". Dworetsky et al. (1984) selected also the four Pt II lines which might be used for astrophysical applications. Moreover, they determined the corresponding theoretical gf values. The aim of this contribution is to investigate the Stark broadening of these Pt II lines and to provide the corresponding Stark widths.

In the case of more complex atoms or multiply charged ions the lack of accurate atomic data needed for more sophisticated calculations diminishes the reliability of the semiclassical results. In such cases approximate methods might be very interesting. Good possibilities provide e.g. the modified semi-empirical method (Dimitrijević and Konjević, 1980), which have been used here for these calculations. Our results for four Pt II lines selected by Dworetsky et al. (1984) as the most interesting ones from an astrophysical point of view, are presented in Table 1. In order to see the influence of the differences in oscillator strengths, results of calculations with gf values obtained by using the Coulomb approximation are presented as well. The differences might give an impression of the error bars in the obtained results.

We can also see from Table 1 that all lines belong to the same supermultiplet and that their widths are not very different. Using the analysis of Stark broadening parameters within a supermultiplet (Dimitrijević, 1982) we can estimate the Stark widths of other members within multiplets and the supermultiplet using $W_1 = (\lambda^2{}_1/\lambda^2{}_2)\ W_2$, taking for W_2 the most appropriate value for the considered case (i.e. e.g. the nearest available member of the same multiplet).

For an order of magnitude estimate, we might use the above mentioned equation, taking for W_2 the data for the transition with the same upper level (or the nearest available member of the same multiplet). For optical Pt II lines given in Dworetsky et al. (1984) and Dworetsky and Vaughan (1973), we might scale by this relation the λ = 2245.5 Å data for the λ = 4148.30 Å, 4061.66 Å, 4034.17 Å, 4023.81 Å and 3447.78 Å lines; the λ = 1781.9 Å data for the 3806.91 Å line and the λ = 2144.2 Å data for the λ = 4514.17 Å, 4288.40 Å, 4046.45 Å, 3766.40 Å, and 3577.20 Å lines.

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 337–338.

TABLE 1

Full Stark widths in Å of astrophysically important Pt II lines as a function of temperature T in K. The electron density is 10^{17} cm^{-3}. The Stark width W_1 has been calculated by using oscillator strengths of Dworetsky et al. (1984) and W_2 with oscillator strengths calculated with the Coulomb approximation.

Transition	λ(Å)	T(K)	W_1(Å)	W_2(Å)
Pt II $6s^4F_{9/2} - 6p^4G_{11/2}$	1777.1	5000	0.0496	0.0353
		10000	0.0351	0.0249
		20000	0.0248	0.0176
		40000	0.0176	0.0125
		80000	0.0124	0.00882
Pt II $6s^4F_{7/2} - 6p^4G_{9/2}$	2245.5	5000	0.0529	0.0557
		10000	0.0374	0.0394
		20000	0.0264	0.0279
		40000	0.0187	0.0197
		80000	0.0132	0.0139
Pt II $6s^4F_{9/2} - 6p^4F_{9/2}$	1781.9	5000	0.0502	0.0358
		10000	0.0355	0.0253
		20000	0.0251	0.0179
		40000	0.0177	0.0127
		80000	0.0125	0.00895
Pt II $6s^4F_{9/2} - 6p^4D_{7/2}$	2144.2	5000	0.0692	0.0484
		10000	0.0489	0.0342
		20000	0.0346	0.0242
		40000	0.0245	0.0171
		80000	0.0174	0.0122

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6. Be STARS:
CIRCUMSTELLAR ENVIRONMENT

1993IAUS..155..189M

RADIATION CHARGE EXCHANGE AND RADIATION ION-ATOM RECOMBINATION AS A SOURCE OF CONTINUAL E–M RADIATION FROM ASTROPHYSICAL PLASMA

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We show that for the study of emission from weakly ionized low temperature hydrogen plasmas, the processes $A^+ + A \rightarrow A^+ + A + \hbar\omega$ and $A^+ + A \rightarrow A_2^+ + \hbar\omega$ (where A denotes a neutral atom in ground state and, A^+ and A_2^+ atomic and molecular ions) must be treaded as a source of continual electro–magnetic radiation from low temperature plasma. Both reaction channels are treated separately and the corresponding total and separate spectral intensities are determined for hydrogen plasma at $T < 10000K$. The obtained results have been also compared with the corresponding spectral intensities for electron–ion bremsstrahlung and electron–ion photorecombination.

Our results (which will be published in Mihajlov et al.,1992) show that in the case of low temperature plasma one must particularly be carefull concerning the continuous EM–radiation spectrum nature. Namely, at typical values of electron and atom component ratio in hydrogen plasma, investigated ion–atom radiation processes might completly determine the character of spontaneous EM–radiation spectrum. We expect similar results in the case of helium plasma. If this fact is not taken into account, serious errors in plasma diagnostic might follow. The important astrophysical cases of interest are hydrogen clouds, circumstellar hydrogen shells and e.g. solar photosphere and chromosphere.

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STARK BROADENING PARAMETERS OF C IV LINES FOR STELLAR PLASMA RESEARCH

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In order to complete available C IV broadening data needed for stellar plasma research, we have calculated Stark broadening parameters for 69 C IV multiplets of large principal quantum number. The results along with a discussion of the Stark broadening parameter regularities within spectral series will be published elsewhere (Dimitrijevic and Sahal-Brechot, 1992). As an example in Figs 1 and 2 the case of C IV $np^2P^0 - 9s^2S$ transitions, is presented. We can see that particularly for shifts the changes of Stark broadening parameters are relatively small, permitting the interpolation of new data or critical evaluation of mutual consistency of existing data.

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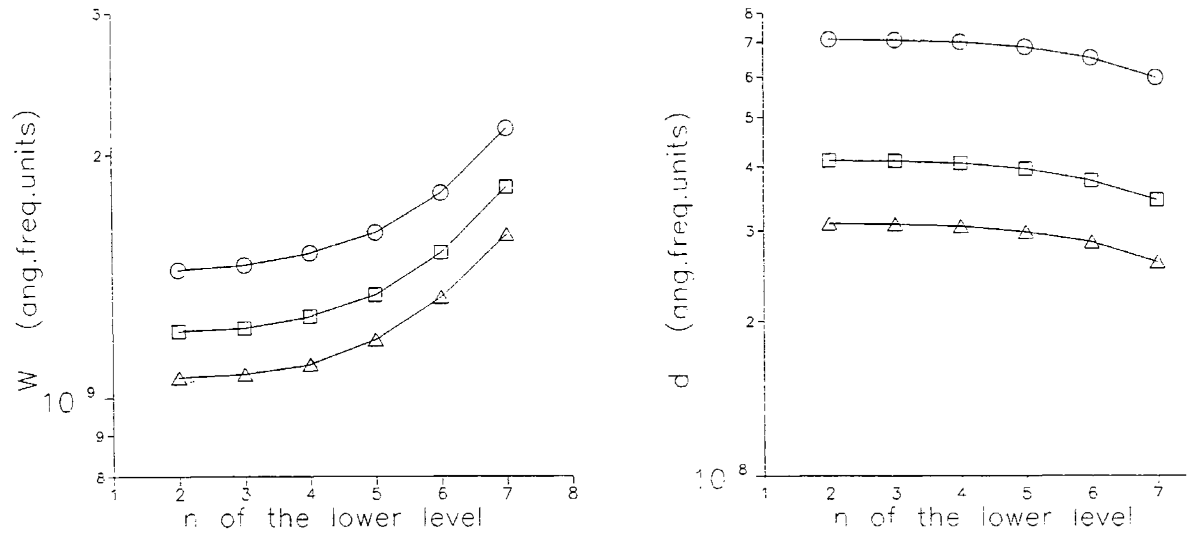

Fig. 1. Figure 1a, 1b. Stark full half widths (1a) and shift (1b) for the C IV $np^2P^0 - 9s^2S$ lines as a function of n for T=20,000K (circles); T=100,000K (squares) and 200,000K (triangles) at $N_e = 10^{13} cm^{-3}$

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STARK WIDTHS OF ASTROPHYSICALLY IMPORTANT FOUR- AND FIVE-TIMES CHARGED ION LINES

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Important astrophysical applications of Stark broadening of spectral lines of multiply charged ions are in the physics of stellar interiors (Seaton 1987). In subphotospheric layers, the modelling of energy transport requires radiative opacities and thus, certain atomic processes must be known accurately. At these high temperatures (10^5 K or more) and densities ($10^{17} - 10^{22}\mathrm{cm}^{-3}$) Stark broadening of strong multicharged ionic lines plays a non-negligible role in the calculation of the opacities, especially in the UV. Moreover, with the development of spectroscopic investigations from space, UV and extreme UV spectral line research has been further stimulated.

In order to provide such data for four- and five-times charged ions, comprehensive studies of electron-, proton- and ionized helium-impact broadening parameters for 30 N V (Dimitrijević and Sahal-Bréchot 1992a), 30 O VI (Dimitrijević and Sahal-Bréchot 1992b) and 21 S VI (Dimitrijević and Sahal-Bréchot 1993) multiplets have been made recently, by using the semiclassical perturbation approach (Sahal-Bréchot 1969ab). In the case of C V, O V and P V lines, there exist sufficient atomic data for sophisticated semiclassical calculations for some or all astrophysically interesting lines. But, for other four- and five-times charged ions, the atomic data set is not sufficiently complete.

In order to complete the Stark broadening data for four- and five-time charged ions, Stark widths of astrophysically important spectral lines within 3 C V, 50 O V, 12 F V, 9 Ne V, 3 Al V, 6 Si V, 11 N VI, 28 F VI, 8 Ne VI, 7 Na VI, 15 Si VI, 6 P VI and 1 Cl VI multiplets, have been calculated by using the modified semi-empirical approach (Dimitrijević, Konjević, 1980). Results for 159 Stark line widths (FWHM) calculated using the modified semi-empirical approach (Dimitrijević and Konjević 1980) - (WMSE) will be published in Dimitrijević (1993a). Moreover, in order to compare the different theoretical methods, for 88 of the above mentioned multiplets calculations were performed by using the symplified semiclassical approach (Griem, 1974) as well (Dimitrijević, 1993b).

Comparison of the present values with values calculated by using Eq. (526) in Griem (1974) have been performed, and the obtained agreement is satisfactory. As an example, a comparison for the C V $3s^1S - 3p^1P$, N VI $2s^1S - 2p^1P$ and O V $4p^1P - 4d^1D$ cases is presented in Table 1. In comparison with the experiment of Purić et al. (1988) for two O V lines, both approaches give about two times smaller values.

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 335–336.

TABLE 1

Comparison of present results for Stark broadening full half width (WMSE) with values obtained by using Eq. (526) in Griem (1974) (WG). The electron density is 10^{17} cm^{-3}.

Transition	λ(Å)	χ(eV)	T(K)	WMSE(Å)	WG(Å)
C V $3s^1S - 3p^1P$	12202.6	56.6	50000	1.79	1.63
			100000	1.57	1.36
			200000	1.46	1.18
			400000	1.22	1.05
			800000	1.21	0.949
N VI $2s^1S - 2p^1P$	2833.7	2.95	50000	0.700E-02	0.812E-02
			100000	0.516E-02	0.607E-02
			200000	0.420E-02	0.475E-02
			400000	0.357E-02	0.395E-02
			800000	0.305E-02	0.349E-02
O V $4p^1P - 4d^1D$	11913.1	29.2	50000	4.35	4.16
			100000	3.79	3.43
			200000	3.30	2.96
			400000	2.98	2.64
			800000	2.81	2.41

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STARK BROADENING OF STELLAR Pt II LINES

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Lines of Pt II have been discovered in Hg Mn stars by Dworetsky (1969). The analysis of a few strong Pt II transitions, which are also observed in IUE spectra of stars, has shown (Dworetsky et al., 1984) "that Pt is, like Hg, among the most overabundant elements in the atmospheres of Hg Mn stars, with enhancements of the order of 10^4 to 10^5 over the solar system abundances". Dworetsky et al. (1984) selected also the four Pt II lines which might be used for astrophysical applications. Moreover, they determined the corresponding theoretical *gf* values. The aim of this contribution is to investigate the Stark broadening of these Pt II lines and to provide the corresponding Stark widths.

In the case of more complex atoms or multiply charged ions the lack of accurate atomic data needed for more sophisticated calculations diminishes the reliability of the semiclassical results. In such cases approximate methods might be very interesting. Good possibilities provide e.g. the modified semi-empirical method (Dimitrijević and Konjević, 1980), which have been used here for these calculations. Our results for four Pt II lines selected by Dworetsky et al. (1984) as the most interesting ones from an astrophysical point of view, are presented in Table 1. In order to see the influence of the differences in oscillator strengths, results of calculations with *gf* values obtained by using the Coulomb approximation are presented as well. The differences might give an impression of the error bars in the obtained results.

We can also see from Table 1 that all lines belong to the same supermultiplet and that their widths are not very different. Using the analysis of Stark broadening parameters within a supermultiplet (Dimitrijević, 1982) we can estimate the Stark widths of other members within multiplets and the supermultiplet using $W_1 = (\lambda^2{}_1/\lambda^2{}_2)\ W_2$, taking for W_2 the most appropriate value for the considered case (i.e. e.g. the nearest available member of the same multiplet).

For an order of magnitude estimate, we might use the above mentioned equation, taking for W_2 the data for the transition with the same upper level (or the nearest available member of the same multiplet). For optical Pt II lines given in Dworetsky et al. (1984) and Dworetsky and Vaughan (1973), we might scale by this relation the λ = 2245.5 Å data for the λ = 4148.30 Å, 4061.66 Å, 4034.17 Å, 4023.81 Å and 3447.78 Å lines; the λ = 1781.9 Å data for the 3806.91 Å line and the λ = 2144.2 Å data for the λ = 4514.17 Å, 4288.40 Å, 4046.45 Å, 3766.40 Å, and 3577.20 Å lines.

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 337–338.

TABLE 1

Full Stark widths in Å of astrophysically important Pt II lines as a function of temperature T in K. The electron density is 10^{17} cm^{-3}. The Stark width W_1 has been calculated by using oscillator strengths of Dworetsky et al. (1984) and W_2 with oscillator strengths calculated with the Coulomb approximation.

Transition	λ(Å)	T(K)	W_1(Å)	W_2(Å)
Pt II $6s^4F_{9/2} - 6p^4G_{11/2}$	1777.1	5000	0.0496	0.0353
		10000	0.0351	0.0249
		20000	0.0248	0.0176
		40000	0.0176	0.0125
		80000	0.0124	0.00882
Pt II $6s^4F_{7/2} - 6p^4G_{9/2}$	2245.5	5000	0.0529	0.0557
		10000	0.0374	0.0394
		20000	0.0264	0.0279
		40000	0.0187	0.0197
		80000	0.0132	0.0139
Pt II $6s^4F_{9/2} - 6p^4F_{9/2}$	1781.9	5000	0.0502	0.0358
		10000	0.0355	0.0253
		20000	0.0251	0.0179
		40000	0.0177	0.0127
		80000	0.0125	0.00895
Pt II $6s^4F_{9/2} - 6p^4D_{7/2}$	2144.2	5000	0.0692	0.0484
		10000	0.0489	0.0342
		20000	0.0346	0.0242
		40000	0.0245	0.0171
		80000	0.0174	0.0122

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6. Be STARS:
CIRCUMSTELLAR ENVIRONMENT

1997IAUS..180..219D

Stark Broadened Line Profiles of Neutral Strontium Lines in Plasma Conditions

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[2] Observatoire de Paris–Meudon, 92190 Meudon, France

During more than twenty years, we are making a continuous effort to provide Stark-broadening parameters needed for research of astrophysical, laboratory and laser produced plasma. A review of our results is presented in Dimitrijević, 1996). Such data are of interest for the consideration of a number of problems in astrophysics, physics and technology as *e.g.* for stellar plasma diagnostic, opacity calculations, the investigation/modelling of stellar spectra or a particular line, laboratory plasma diagnostic, laser produced plasmas, thermonuclear research, plasma technology, as well as for different examinations of regularities and systematic trends for e.g. homologous atoms (Dimitrijević and Popović, 1989) or in general (Purić *et al.* 1991).

Strontium lines are present in solar and stellar spectra. E.g. Komarov & Basak (1993) have found neutral strontium lines in the spectra of Sun and two Praesepe's stars. They are also of interest since Sr is one of thermonuclear s - processes product in stars and its over-abundance is observed in CH and metal deficient barium stars (Šleivytė & Bartkevičius, 1995).

We have calculated within the semiclassical-perturbation formalism (Sahal–Bréchot, 1969ab) electron-, proton-, and ionized helium-impact line widths and shifts for 33 Sr I multiplets. All details of calculations are given in Dimitrijević and Sahal - Bréchot, 1996a and in references therein. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and He II- impacts have been calculated. Our results for 33 Sr I multiplets, for perturber densities 10^{13} cm^{-3} (for stellar plasma research) and 10^{15}– 10^{18} cm^{-3} (for laboratory plasma research) and temperatures T = 2,500 – 50,000 K, will be published elsewhere (Dimitrijević and Sahal - Bréchot, 1996a,b). The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

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EVOLUTION OF STARS: THE PHOTOSPHERIC ABUNDANCE CONNECTION

DRUZBA, BULGARIA
AUGUST 27 - 31, 1990

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* setting the stage
* the lower main sequence
* the upper main sequence
* the giants
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* the horizontal branch and related phases
* the planetary nebulae
* white dwarfs

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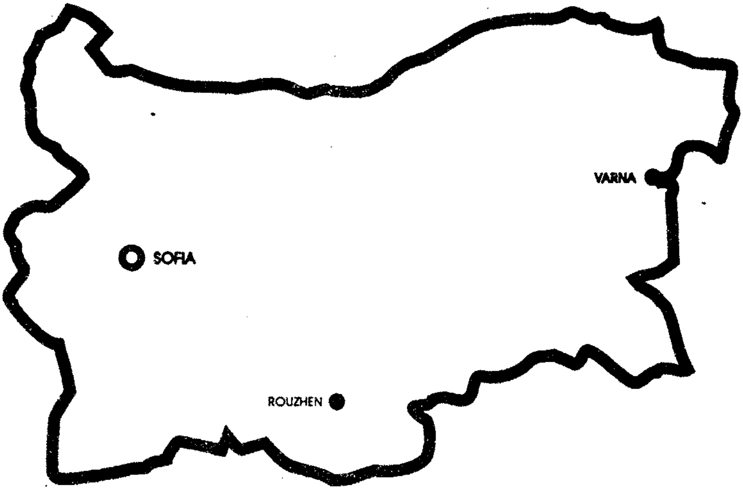

APPROXIMATE METHODS FOR LINE BROADENING CALCULATIONS

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Data on line profiles broadened by collisions with electrons, protons and hydrogen atoms are important for the stellar abundance determinations. Whenever line broadening data for a large number of lines are required tedious calculations can be avoided if one uses simple approximative formulae with good average accuracy. Here a review of such approximate methods with the special emphasys on electron-impact broadening will be presented. Also will be reviewed methods based on the investigations of regularities and systematic trends, enabling interpolation of new data and critical evaluation of available results.

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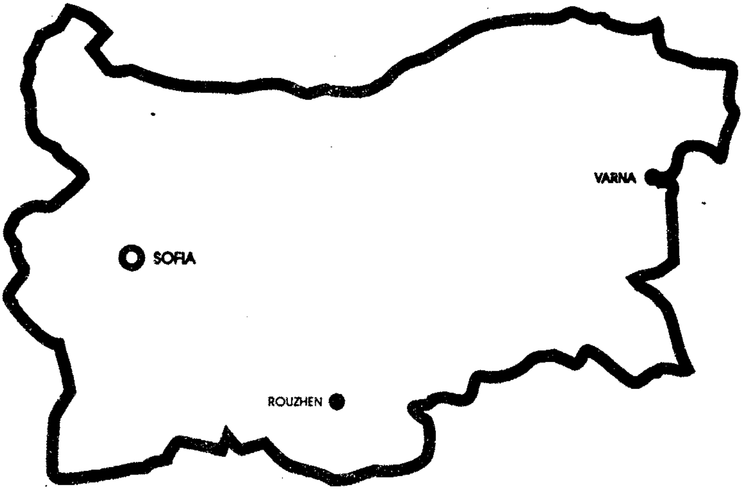

STARK BROADENING OF CIV λ1549 LINES AND CARBON ABUNDANCE IN HOT DA WHITE DWARFS

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Recently, accurate quantum mechanical as well as semiclassical Stark broadening calculations of CIV 2s-2p lines have been published. We have calculated equivalent widths of these lines as a function of effective temperature and carbon abundance in pure hydrogen atmospheres of log g=8, using new theoretical Stark widths. On the basis of the results obtained, we have analysed the importance of accurate Stark broadening parameters for abundance determinations in hot DA white dwarf stars.

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ABSTRACT BOOKLET

II–30: STARK BROADENING PARAMETERS OF C IV LINES FOR STELLAR PLASMA RESEARCH

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We have calculated recently, Stark broadening data for 39 C IV multiplets persuaded that we have provided data for practically all C IV lines important for stellar research. Our tables however are not sufficiently complete for the investigation of PG 1159 stars, which are hot hydrogen deficient pre- white dwarfs with effective temperature 100.000 - 140.000 and with C and He as dominant constituents (C/He = 0.5). Moreover, Stark broadening data in far and extreme ultraviolet, for lines originating from transitions between energy levels with large principal quantum number and low lying levels will become important for astrophysics in the near future due to Extreme Ultraviolet Explorer (EUVE) and the Far Ultraviolet Spectrocopy Explorer (FUSE) missions. In order to complete available C IV Stark broadening data, we present and discuss here Stark broadening parameters for 69 C IV multiplets of large principal quantum number, calculated using semiclassical perturbation approach, along with a discussion of the Stark broadening parameter regularities within spectral series.

II–31: THE DEVELOPMENT OF A ULTRAVIOLET ATOMIC LINE LIST SUITABLE FOR HOT CENTRAL STARS OF PLANETARY NEBULAE

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Until very recently, spectroscopic studies in the ultraviolet using the IUE of hot O-subdwarfs and central stars of planetary nebulae have revealed the vast majority of the photospheric features could not be identified. Many of the other features that could be identified, besides those such as N V and C IV, are Fe V, IV, and VII and similar ions of the Fe-group. Coadded IUE spectra of these hot objects show many other unidentified features. Accurate atomic data for these highly ionized species will be a prerequisite to doing any quantitative analysis. A cooperative effort between astronomers and atomic laboratory spectroscopists has allowed us to identify most of the strong photospheric features in the hottest stars in the $\lambda\lambda$1150-2000 range. We are in the process of making available extensive line lists for these stars. We take advantage of the fact that both the IUE stellar astronomical and laboratory spectra show many unidentified lines. In this project, we use IUE high resolution spectra of O-subdwarfs of different surface temperatures as "ionization filters" as an aid in identifying unidentified features in individual laboratory spectra, which often show several stages of ionization simultaneously. Unidentified, strong features in a particular O-subdwarf must arise from an ion within a specified range of ionization energy. The measured wavelength of these lines are then compared to the laboratory spectra in an attempt to establish coincidences in the laboratory data for ions within the required ionization range. This, in turn, makes the laboratory identification process much easier and allows the energies of additional levels to be determined, plus it concentrates the efforts on only the transitions that are important to astrophysics. With improved energy levels, reliable oscillator strengths are then calculated. Our goal is to expand substantially the database of reliable atomic data for hot stars. High resolution ultraviolet spectroscopy of the sharp-lined central stars of planetary nebulae is expected to benefit greatly from this work.

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ABSTRACT BOOKLET

III–50: TEMPERATURE FLUCTUATIONS IN PN

RUTH GRUENWALD and SUELI M. VIEGAS

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For planetary nebulae, empirical abundances are obtained from the observed emission-lines as long as the electron density, the electron temperature, and the ionization correction factor are determined. Due to temperature fluctuations in the emitting gas, the evaluation of the temperature from the observational data is strongly dependent on the method used. The temperature fluctuation is usually characterized by the mean square temperature fluctuation, t^2 (Peimbert, 1967).

Theoretical t^2 values have been discussed in detail for H II regions (Gruenwald and Viegas, 1992). These results show that t^2 decreases with the gas density. The stellar temperature is also an important parameter, but the t^2 dependence is not monotonic. Although planetary nebulae are denser, the stellar temperature can be higher than that of the H II region ionizing star. The temperature fluctuation could then still be important.

Theoretical t^2 values are obtained for typical planetary nebulae conditions from photoionization models. The effect of high stellar temperature is to increase t^2, and temperature fluctuations can be important even considering high densities. The empirical abundances of observed planetary nebulae with high stellar temperature are discussed.

III–51: RADIATIVE CHARGE EXCHANGE AN RADIATIVE ION-ATOM RECOMBINATION AS A SOURCE OF CONTINUAL E-M RADIATION FROM ASTROPHYSICAL PLASMA

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We show that for the study of emission from weakly ionized low temperature hydrogen plasmas, the processes

$$A + A^+ \rightarrow A_2^+ + \hbar\omega \tag{1}$$

$$A + A^+ \rightarrow \begin{cases} A + A^+ \\ A^+ + A \end{cases} + \hbar\omega \tag{2}$$

(where A denotes a neutral atom in ground state, and A^+ and A_2^+ atomic and molecular ions) must be treated as a source of continual e-m radiation from stellar plasma. Both reaction channels are treated separately and the corresponding total and separate spectral intensities are determined for hydrogen plasma at $T \lesssim 10^4$ K. The obtained results have been also compared with the corresponding spectral intensities for electron-ion photorecombination.

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THE CARBON STAR PHENOMENON

Program and Abstracts

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Stark Broadening Data for the Conditions of Carbon Star Plasma

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[1] Astronomical Observatory, Belgrade, Yugoslavia
[2] Observatoire de Paris, Meudon, France

We intend to provide, within the framework of our long-term program, reliable Stark broadening data needed for spectrum synthesis, atmospheric modelling, opacity calculations, abundance determinations, radiative transfer, plasma diagnostics and research on subphotospheric layers. The importance of such results increases with increasing temperature and electron density. They are of particular significance, for example, for the investigation of PG 1159 stars, which are hot hydrogen-deficient pre–white dwarfs with effective temperatures of 100,000–140,000 K and with C and He as dominant constituents (C/He = 0.5). Such data are of interest as well for subphotospheric layers in cool carbon stars. The development of space astronomy increases the astrophysical significance of lines in the far and extreme ultraviolet, originating from transitions between energy levels with large principal quantum number and low-lying levels, as well as the significance of far infrared lines. As the principal quantum number increases, the importance of Stark broadening also increases, and the range of relevant stellar plasma conditions increases as well. Here we present and discuss Stark broadening data of interest for carbon-star research that we have obtained to date, and we discuss the future objectives of our program.

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Stark Broadened Line Profiles of Neutral Strontium Lines in Plasma Conditions

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During more than twenty years, we are making a continuous effort to provide Stark-broadening parameters needed for research of astrophysical, laboratory and laser produced plasma. A review of our results is presented in Dimitrijević, 1996). Such data are of interest for the consideration of a number of problems in astrophysics, physics and technology as *e.g.* for stellar plasma diagnostic, opacity calculations, the investigation/modelling of stellar spectra or a particular line, laboratory plasma diagnostic, laser produced plasmas, thermonuclear research, plasma technology, as well as for different examinations of regularities and systematic trends for e.g. homologous atoms (Dimitrijević and Popović, 1989) or in general (Purić *et al.* 1991).

Strontium lines are present in solar and stellar spectra. E.g. Komarov & Basak (1993) have found neutral strontium lines in the spectra of Sun and two Praesepe's stars. They are also of interest since Sr is one of thermonuclear s - processes product in stars and its overabundance is observed in CH and metal deficient barium stars (Šleivyté & Bartkevičius, 1995).

We have calculated within the semiclassical-perturbation formalism (Sahal–Bréchot, 1969ab) electron-, proton-, and ionized helium-impact line widths and shifts for 33 Sr I multiplets. All details of calculations are given in Dimitrijević and Sahal - Bréchot, 1996a and in references therein. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and He II- impacts have been calculated. Our results for 33 Sr I multiplets, for perturber densities 10^{13} cm^{-3} (for stellar plasma research) and $10^{15}-10^{18}$ cm^{-3} (for laboratory plasma research) and temperatures $T = 2{,}500 - 50{,}000$ K, will be published elsewhere (Dimitrijević and Sahal - Bréchot, 1996a,b). The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

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List of Participants

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Planetary Nebulae

University of Groningen
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Stark broadened line profiles of neutral Strontium lines in stellar plasma conditions

I-39

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Strontium lines are present in solar and stellar spectra. E.g. Komarov & Basak (1993) have found neutral strontium lines in the spectra of Sun and two Praesepe's stars. They are also of interest since Sr is one of thermonuclear *s* – processes product in stars and its overabundance is observed in CH and metal deficient barium stars. Neutral strontium lines are also of interest for the investigation of laboratory plasmas. Consequently, Kato et al. (1984) investigated wavelength shifts of Sr I lines emitted by an inductively coupled plasma and Karabut et al. (1980) dynamics of strontium line shapes during a pulsed discharge. Such lines have been considered theoretically as well by Davis (1972), for research of a laser - generated barium plasma. In order to continue our research of Stark broadening parameters needed for the investigation of astrophysical and laboratory plasmas and to provide the needed Stark broadening data, we have calculated within the semiclassical-perturbation formalism electron-, proton-, and ionized helium-impact line widths and shifts for 33 Sr I multiplets. The obtained data will be presented and discussed here.

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ABSTRACT BOOK

IAU Symposium No. 210

Modelling of Stellar Atmospheres

Edited by Eric Stempels

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VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

DATA GATE

E63

The investigation of spectrum roAp star HD101065 (Przybylsky's star) in Li I 6708 A region

A. Shavrina [1], N. Polosukhina [2], M. Hack [3], M. Dimitrievich [4], V. Gopka [5], Y. Pavlenko [1], J. Zverko [6], J. Ziznovsky [6], A. Yushchenko [5], P. Quinet [7]

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[7] *Astrophysique et Spectroscopie Universite de Mons-Hainaut, B-7000 Mons(Belgium)*

We have considered the possibility for modeling of remarkable spectral feature 6708 Å for HD 101065 (Przybylsky's star) in two ways - as a blend of Li and REE and other heavy elements lines and as blend without lithium lines. Best agreement between synthetic and observing spectra is with Li abundance near $lgN(Li) = +2.6$ *dex*. We searched REE elements spectra in the vicinity of Li 6708 line and calculated gf values for lines with unknown gf. We calculated individual atmosphere model of the star taking into account absorption in REE lines with new chemical composition. We have found absorption lines of several heavy elements with atomic numbers $Z >$ 72. The overabundances of these elements are near 4 *dex*. Significant part of lines in the spectrum of the star are still unidentified.

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DATA GATE

B2

Chemi-ionization/recombination and radiation processes in atom-atom and ion-atom collisions in the modeling of low-temperature stellar atmospheres

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Results of our investigations of the influence of chemi-ionization, chemi-recombination and radiation processes in atom-atom and ion-atom collisions (in the case of the symmetric atom-atom and ion-atom systems) in stellar hydrogen and helium plasmas are presented.

The considered chemi-ionization and chemi-recombination processes influence significantly on the electron density and the excited atomic energy level populations, and the considered ion-atomic radiation processes influence significantly on the optical characteristics of stellar plasma. The consequence of the obtained results is that they should be taken into account for the modeling of photosphere and low chromosphere of the Sun and similar stars (hydrogen case) and white dwarf atmospheres (helium case).

ABSTRACT BOOK

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DATA GATE

B9

Stark shifts and transition probabilities in Si III spectra

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Atomic data such as Stark broadening parameters and transition probabilities play an important role in the diagnostics and modeling of various cosmic and laboratory plasmas, in particular in the modeling of stellar atmospheres. Silicon is among the most abundant chemical elements and the astrophysical significance of the corresponding atomic data is obvious

Stark shifts of nine doubly charged silicon ion spectral lines have been measured in a linear, low-pressure, pulsed arc operated in O2 and SF6 discharges. Si III Stark shifts values have been also calculated using the semiclassical perturbation formalism. Moreover the transition probabilities of the spontaneous emission of nine Si III transitions have been obtained using the relative intensity ratio method, not applied before in the Si III spectrum, and also calculated using the Coulomb approximation method. The measured and calculated shifts and transition probabilities have been compared to the existing data.

ICAMDATA 7

21–24 September 2010, Vilnius

State of the development of the STARK-B database in the framework of the European Project VAMDC (Virtual Atomic and Molecular Data Center)

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Stark broadening theories and calculations have been extensively developed for about 50 years. The theory can now be considered as mature for many applications, especially for accurate spectroscopic diagnostics and modelisation. This requires the knowledge of numerous collisional line profiles, especially for very weakly abundant atoms and ions which are used as useful probes for modern spectroscopic diagnostics. Nowadays, the accces to such data via an on line database becomes indispensable.

STARK-B [1] has been a collaborative project between the Astronomical Observatory of Belgrade and the Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique (LERMA) for a few years. It is a database of calculated widths and shifts of isolated lines of atoms and ions due to electron and ion collisions (i.e. impacts are separated in time). This database is devoted to modelisation and spectroscopic diagnostics of stellar atmospheres and envelopes. In addition, it is relevant to laboratory plasmas, laser equipments and technological plasmas. Hence, the domain of temperatures and densities covered by the tables is wide and depends on the ionization degree of the considered ion.

STARK-B is a part of VAMDC [2]. VAMDC (Virtual Atomic and Molecular Data Centre) is an European Union funded collaboration between groups involved in the generation and use of atomic and molecular data. VAMDC aims to build a secure, documented, flexible and interoperable e-science environment-based interface to existing atomic and molecular data.

STARK-B has been fully opened since September 2008 though not yet complete. We will present the advancement of its development at the Conference.

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[1] http://stark-b.obspm.fr

[2] http://www.vamdc.eu

1st General Conference
of the
Balkan Physical Union

ABSTRACTS

September 26-28, 1991
THESSALONIKI, Greece

2 TP 809

ON THE INFLUENCE OF CURVILINEAR TRAJECTORIES ON STARK BROADENING OF HYDROGEN LINE WINGS

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Within the semiclassical and classical formalism for the line-shape calculations, the trajectory of perturber is commonly represented by a straight line. However, at low temperatures the effect of non-uniform motion of perturber due to the interaction of emitter may become noticeable (1).

It was found also (2) that the non-uniform perturber motion may influence the far line-wings in the case of hydrogen. It was found that the effect is noticeable for particular fine structure transitions between states with different parabolic quantum numbers especially in the case of Rydberg states (2).

Here, we tried to answer the question, how noticeable is this effect if the complete line-wing shape is calculated, since this procedure averages the influence of particular components. We performed calculations using the Unified theory of Greene et al (3,4) modified for the case of curvilinear trajectories (2). Obtained results show that the averaging over different components considerably diminishes the influence of the investigated effect in the case of Rydberg atoms.

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1st General Conference
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ABSTRACTS

September 26-28, 1991
THESSALONIKI, Greece

AN INVESTIGATION OF THE SIMPLE FORMULAE FOR STARK WIDTH AND SHIFT CALCULATION OF NEUTRAL ATOM LINES

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Astronomical Observatory, Volgina 7, 11050 Beograd,
Yugoslavia

Whenever line broadening data for a large number of lines are required, and the high precision of every particular result is not so important, simple approximative formulae with good average accuracy may be very useful. For the astrophysical purposes, of particular interest might be the symplified semiclassical approach (1).

Using this approach, we have calculated Stark broadening widths and shifts for 42 neutral helium multiplets, in order to obtain an extensive data set for the investigation of possibilities and applicability of the mentioned approach.The obtained results have been compared with the more sophysticated semiclassical calculations (2,3), as well as with the more simple approximate formula(40). We performed also an analysis of the influence of the number of perturbing levels used in the calculation, as well as the analysis of the applicability and accuracy of this approach in function of the increase of the principal quantum number for the upper level of the transition, within a spectral series. The number of perturbing levels included in the calculations may become particularly critical in the case of the shift where even the sign may be changed if a more complete set of perturbing levels is used.

Results indicate that the analyzed approach may be very useful for simple calculations when only a good average accuracy is needed and the high precision of every particular result is not so important.

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Be STARS - CHALENGE TO THE OBSERVERS AND THEORETICIANS

J.Arsenijević, A.Kubičela and I.Vince

Astronomical Observatory,Volgina 7,11050
Beograd,Yugoslavia

The main historical steps in the investigation of the B stars with emission lines,starting with the year 1922 when IAU Comission 29 introduced the name "Be stars" at the first General Assembly of the Union in Rome and closing with the IAU Colloquium No.92 "Physics of Be Stars" organized in August 1986 in Boulder, are briefly reviewed.

The enormous quantity of the existing observational data and their significant characteristics over broad spectral region from X-ray to radio wavelengths are discussed. One of the main characteristics - photometric and spectral time variability - is analysed with a special attention to long-term changes.

The long-term photometric and spectral changes are correlated with the polarimetric ones for the stars from the Belgrade program of long-term polarimetric study of Be stars started in 1974.

Observational results in confrontation with the theoretical interpretations from Struve´s hypothesis to the contemporary empirical Be stars models are presented.

THE ANGULAR VELOCITY OF SPIRAL ARMS AND THE SPACIAL DISTRIBUTION OF GALACTIC CIVILIZATIONS

Béla A. Balázs
Department of Astronomy
Loránd Eötvös University
Budapest, Hungary

Abstract:

The gravitational density wave theory of C.C. Lin and his co-workers is currently the most popular of theories which can provide an acceptable quantitative viewpoint from which it is possible to explain the large-scale galactic spiral structure in a coherent way. This contribution makes use of some stellar astronomical results based on Lin's theory and on the galactic distribution of open clusters of various ages. Relying upon the cluster distribution it is possible to determine the geometry and angular velocity of the rigidly rotating spiral pattern. It turns out that the orbit of the Sun is close to the so called co-rotation circle. Consequently, if we assume that the case of mankind is about average and accept the idea that the longevity of a civilization might be limited with high probability by catastrophic events threatening during the crossing of galactic arms, intelligent life is presumably concentrated on a belt in the Galaxy which is a narrow annulus including the co-rotation circle and the galactic orbit of our Sun.

Current estimates of the likelihood, galactic distribution and accessibility of extra-terrestrial civilizations generally contain three shortcomings: They treat our Galaxy as a homogeneous , isotropic and steady-state system and not as an object of specific geometric and kinematic properties with reasonably well understood morphology and path of evolution. If the galactic belt of intelligent life is a reality at least the first and last factors in the "Drake Equation" must be reassessed. (The number of suitable stars in the belt is only of the order of 10^8 and the average longevity of a civilization needs to be judged in comparison with the time which its system spends between two neighbouring spiral arms.) Supposing that intelligent life will develop on the same time-scale, by the same rules wherever the proper surroundings and the needed time are given, it is possible to locate a zone of advanced civilizations where societies at least as old as ours are primarily expected. From heliocentric point of view the distribution of our potential extraterrestrial partners is highly anizotropic: in a small solid angle around the line of sight there are about 10^3 times as many of them in the tangential directions than towards the galactic anticentre.

ON THE ROLE OF SOME SPECIAL TYPES OF STARS IN CONTEMPORANEOUS GALACTIC ASTRONOMY

Slobodan Ninković

Astronomska opservatorija, Volgina 7,
11050 Beograd

The present author tries to point out some special types of stars, distinguished by astrophysicists according to their physical properties, which may be particularly useful to a study of our Galaxy.

SS 433 OBJECT

Tomaž Zwitter

Oddelek za fiziko, Jadranska 19, 61000 Ljubljana

ON THE C IV LINE PROFILES IN THE WHITE DWARFS

Ištvan Vince and Milan S. Dimitrijević
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The equivalent width and the shift of stellar absorption lines depend on the Stark broadening especialy in the case of white dwarfs and early type stars (O, B and A). Even in the cooler star atmospheres Stark broadening may be important for higher members of a spectral series (Vince et al, 1985) or in the wings of the Voigt profile.

In this communication we present the equivalent width calculations within $2s^2S - np^2P^o$ series of C IV lines, using the white dwarf atmosphere model with $T_{eff} = 35000$ K and log g = 8. (Wesemael et al, 1980). Our aim is (i) to study the behaviour of equivalent widths within 2s - np spectral series of C IV, (ii) to compare the Stark broadening mechanism with other effects influencing line shapes, as well as (iii) to provide new accurate spectroscopic data for important C IV lines in white dwarfs spectra.

Our results for the shift and the equivalent width of C IV spectral lines, for different abundances of carbon ($A = A_{\odot}$, $A = A_{\odot}/100$ and $A = A_{\odot}/1000$, where $A_{\odot} = 3.3113\ 10^{-4}$) are presented in Table. For the Stark broadening contribution, the new semiclassical results (Dimitrijević and Sahal-Bréchot, 1988) have been used. All calculations have been performed using LTE assumption.

Table. Equivalent widths (W) and line shifts (d) for C IV $2s^2S - np^2P^o$ spectral lines, for different carbon abundances A.

Transition	$A = A_\odot$		$A = A_\odot/100$		$A = A_\odot/1000$	
Wavelength (nm)	W(nm)	d(nm)	W(nm)	d(nm)	W(nm)	d(nm)
$2s^2S-2p^2P^o$ 154.9	0.227	-1.11-4	2.159-2	-1.28-4	5.74-3	-1.19-4
$2s^2S-3p^2P^o$ 31.2	0.166	-9.82-5	1.58-2	-1.13-4	4.75-3	-1.13-4
$2s^2S-4p^2P^o$ 24.5	0.349	-9.25-4	3.40-2	-9.87-4	7.91-3	-1.05-3
$2s^2S-5p^2P^o$ 22.3	0.300	-2.79-4	3.85-2	-3.37-3	6.27-3	-3.35-3

Our conclusion is that the Stark broadening is dominant in present case and that W/λ^2 and $|d|/\lambda^2$ increase regularly within C IV $2s^2S-np^2P^o$ spectral series.

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COSMIC SYNCHROTRON RADIATION

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Electromagnetic waves from the cosmic space have their origin in variety of mechanisms The most important contribution in the radio region is resulting from radiation of relativistic electrons moving in magnetic fields. This type of emission, called synchrotron radiation or magnetobremsstrahlung, has been recorded in other spectral regions also but as a minor component.

The synchrotron emission has been recorded from the Sun (some types of bursts), Earth, Jupiter, Saturn, Uranus, (as planetary magnetic belts effects), Galaxy (e.g. spurs, supernova remnants, pulsars, SS433, galactic centre source, galactic background)and extragalactic sources (galaxies, quasars).

The main characteristics of the synchrotron radiation from a typical cosmic source are: a high degree of linear polarization and a decrease of intensity with frequency in the major part of the radio region. These features make it distinctly different from the blackbody radiation at temperatures recorded in the cosmic space; the blackbody radiation is unpolarized and increases with frequency in the radio region.

A typical spectrum of a synchrotron type radio source can be represented by a power law $S \propto f^{-\alpha}$, where S is the flux density, f is the frequency and α is the spectral index. Although a strictly straight logS -logf spectrum is observed only for some radio sources, the spectral index is widely used as a measure of steepness of the spectrum between two frequencies. The straight spectrum sources usually have the value of spectral index close to 0.8 . It can be expected that spectral indices change with time, as it has been found for CasA. Many spectra start to bend down at frequencies near several MHz, but some spectra bend down near several GHz or exhibit even more complex behaviour. The deflections can be explained as due to: (1) variations in the electron energy distribution which may exist either in the initial distribution or occur as a result of energy loss, (2) self-absorption in the relativistic gas, (3) absorption in a HII region, (4) the effect of a dispersive medium in the source.

Several types of models have been developed for interpretation of the observed radio spectra. The simplest one assumes an ensemble of electrons which is homogeneous and isotropic, in a uniform magnetic field, with the energy distribution function $N(E)=N_0E^{-\gamma}$ for a limited energy range. In such a case a simple relation follows: $\gamma=1+2\alpha$. The degree of linear polarization is then $\Pi=(\gamma+1)/(\gamma+7/3)$ with the electric vector being a maximum perpendicular to the projection of the magnetic field. Application of the model to the galactic background spectrum near the galactic poles gave γ close to the value obtained from cosmic ray measurements, implying that many cosmic rays originate in the Galaxy and produce the galactic background radiation. The radio polarization results apart from support to the optical interstellar polarization data can tell about the magnetic field in the source. Both examples show only a part of possibilities to be used in future.

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QUASI-PERPENDICULAR ION-CYCLOTRON INSTABILITY IN PLASMAS CONTAINING IONS WITH TWO TEMPERATURES

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Comparatively recent experimental data obtained from the geostationary satellites[1] led to the conclusion that the presence of ions with different temperatures is of utmost significance for the characteristics of the ion-cyclotron instability excited in the geomagnetically trapped plasma[2,3]. The general problem of the properties of the ion cyclotron waves in multispecies plasmas has received considerable attention[4,5], but the analysis was usually based either on the 'cold' plasma model, or on the hydrodynamic description of the process, in spite of the fact that the necessity of using the kinetic theory in these studies has long been known[6,7]. The kinetic ~~approach~~ approach allowed to establish that the ion cyclotron waves propagated almost perpendicularly with respect to the external magnetic field may become unstable, due to the presence of the electron drift exceeding some threshold value, also at extremely long wavelengths[8,9], and this situation is of particular interest in both the geomagnetically trapped plasma and many other astrophysical problems.

The present analysis of the phenomenon of spontaneous excitation of ion cyclotron waves by electron drift in a multi-species and multi-temperature plasma is based on the model of infinite, collisional and magnetized current-carrying plasma, with the current flowing along the lines of force of the external homogeneous magnetic field $\vec{B}_0$. This current is accounted for by taking that the ions are at rest, whereas the electrons have a drift velocity of intensity u_e directed along $\vec{B}_0$. Apart from the electrons (steady-state concentration n_e, temperature T_e), the plasma contains only one sort of single-charged ions (for example, H^+ in the geomagnetically trapped plasma), but divided into two groups with different concentrations and temperatures (n_1, T_1 and n_2, T_2). The steady-state distribution functions for all the particles are taken to be Maxwellian with corresponding temperatures, assumed isotropic. The steady-state quasi-neutrality condition reads $n_e = n_1 + n_2$, and the plasma composition is suitably expressed by the dimensionless parameter $\tilde{n} = n_1/n_2$. Although the 'cold' and the 'hot' ions have the same ionic mass m_i, and consequently a common cyclotron frequency $\omega_{Bi} = eB_0/m_i$, they have different temperatures; letting $T_2 > T_1$ one also has $v_{T2}/v_{T1} = (T_2/T_1)^{1/2} > 1$ and $\nu_2/\nu_1 = v_{T2}/v_{T1} > 1$.

The attention is focused here on the long-wave ion cyclotron waves in the vicinity of the rth harmonic ($\omega \approx r\omega_{Bi} \equiv \Omega_r$). The dispersion equation for quasi-perpendicular electrostatic waves is of the form $\delta\varepsilon_e + \delta\varepsilon_i = 0$, where the ionic and the electronic contributions were evaluated previously[9]. Neglecting the exponentially small Landau damping term, which is irrelevant in the domain of very long waves ($\nu_e \gg k_\parallel v_{Te}$ and $\omega\nu_e \ll k_\parallel^2 v_{Te}^2$) where the collisions are dominant, one thus arrives at the following expressions for the spectrum and the condition of marginal instability:

$$\frac{\omega}{\omega-\Omega_r} = \frac{1+\tilde{n}(T_1/T_2)+(1+\tilde{n})(T_1/T_e)}{A_r(\mu_1)+\tilde{n}(T_1/T_2)A_r(\mu_2)}, \qquad \frac{u_e}{v_{T1}} = \frac{\omega}{\omega-\Omega_r}\left(\xi+\frac{Q}{\xi}\right), \qquad (1)$$

where $\xi = (\omega-\Omega_r)/k_\parallel v_{T1}$, $A_r(z) = e^{-z}I_r(z)$ (I_r is the modified Bessel function), $\mu_s = k^2 v_{Ts}^2/\omega_{Bi}^2$ ($\mu_2 = (T_2/T_1)\mu_1$ for the case considered), and $Q = (T_e/T_i)^{3/2}(m_i/m_e)^{1/2}(1+\tilde{n})^{-1}\left[1+(T_1/T_2)^{1/2}\tilde{n}\right]$. It is immediately seen from the above expressions that the threshold value of the electron drift is $(u_e/v_{T1})_{min} = 2\,Q^{1/2}\left[\omega/(\omega-\Omega_r)\right]$.

An inspection of the results (1) discloses that, in view of the form of the functions A_r, the influence of the 'hot' ionic component will be particularly prominent for $\mu_1 \ll 1$, provided that μ_2 lies in the vicinity of the maximum of the corresponding A_r-function (this is $\mu_2 = 1.5$ for $r = 1$, or $\mu_2 = 9.6$ for $r = 3$, for example).

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LANDAU DAMPING OF THE TRANSVERSE ELECTROMAGNETIC WAVE IN MULTI-SPECIES PLASMAS WITH POLARIZABLE HEAVY PARTICLES

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In practically all considerations of the transverse electromagnetic waves propagated in both laboratory and astrophysical plasmas, it is taken for granted that these waves undergo no collisionless (Landau) damping, in view of the fact that their phase velocity v_{ph} is larger than c, the velocity of light in vacuum, so that the presence of resonant particles is excluded by the requirements of the theory of relativity. A more careful analysis of this conclusion discloses, however, that the requirement $v_{ph} > c$ unconditionally holds in plasmas the ions of which are point charges, which is strictly true in fully ionized hydrogen plasma only. In all other cases, including the partially ionized hydrogen, the plasmas actually contain heavy particles with fully or partly preserved electronic envelopes and, consequently, with dynamic polarizability different from zero. The presence of such particles may alter the spectral properties of the plasma transverse waves (and, presumably, of other plasma modes as well). In particular, this may entail the diminishment of their phase velocity which, under certain conditions, may become smaller than c, so that the Landau damping will become possible.

The effect of the Landau damping of the transverse electromagnetic waves in a homogeneous and non-magnetized plasma containing only one sort of heavy and polarizable particles was already studied to some extent[1]. In this paper a more general case of weakly ionized plasma containing several species of heavy polarizable particles is considered. These particles emit at frequencies $\omega_{ls}^{(\beta)} = (E_l - E_s)/\hbar$ ($\beta = 1,2,\ldots,q$ labels the particle species, and l, s refer to the energy levels of the exterior bound electron in the dipoles pertaining to the heavy particles). It is found here that $v_{ph} < c$ is possible if:

$$\omega \ll \omega_{ls}^{(\beta)}, \tag{1}$$

for all β and all l and s. It is also established that with $\omega \gg \omega_{ls}^{(\beta)}$ for all β and all l and s, one definitely has $v_{ph} > c$.

The condition (1) is necessary, but not sufficient for $v_{ph} < c$ to hold. The solution of the relevant dispersion equation, with the terms accounting for the polarizability of the heavy particles included, reveals that the sufficient condition for the possibility of existence of the Landau damping of the transverse electromagnetic plasma wave is of the form:

$$\omega_{pe} < ck \left[\sum_{\beta=1}^{q} \sum_{l<s} \left(\frac{\Omega_{ls}^{(\beta)}}{\omega_{ls}^{(\beta)}} \right)^2 \right]^{1/2}. \tag{2}$$

Here, $\omega_{pe} = (e^2 n_e / \varepsilon_0 m_e)^{1/2}$ is the electron plasma frequency, $\omega_{ls}^{(\beta)}$ has the meaning explained above, and

$$\left(\Omega_{ls}^{(\beta)} \right)^2 = \frac{e^2}{\varepsilon_0 m_e} \left(n_l^{(\beta)} - n_s^{(\beta)} \right) f_{ls}^{(\beta)} \tag{3}$$

with $n_l^{(\beta)}$ and $n_s^{(\beta)}$ denoting the population densities of the corresponding energy levels of the atoms of the species β , and $f_{ls}^{(\beta)}$ standing for the associated oscillator strengths. It is readily seen that the condition (2) will be most easily met in the short-wave domain, $\omega_{pe}^2 \ll c^2 k^2$.

The above possibility of Landau (collisionless) damping of the transverse electromagnetic plasma wave in multispecies plasmas is of considerable interest in astrophysics and radio-astronomy, as the condition (2) may be satisfied for a broad class of astrophysical plasmas, and for electromagnetic waves within a large domain of wavelengths, ranging from long radio-waves to the UV part of the spectrum. The predicted effect of the Landau damping seems to be particularly significant for solar and stellar atmospheres, where the role of the resonant particles might be taken over by the very fast particles present in these plasmas due to the corpuscular beams emitted from the stellar surfaces as a result of the processes taking place there.

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ON SOME METRIC PROPERTIES OF TWO ALTERNATIVE THEORIES OF THE GRAVITATIONAL FIELD

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We consider: 1) Rosen's *bimetric gravitation theory*, [1],[2] ; 2) Logunov's *relativistic gravitation theory*, [3],[4] (in fact also a bimetric theory). The metric, or gravitational field, tensor in both theories is subject to conformal transformations, and some properties of conformally equivalent metrics are established [5], [6]. The consequences of the conservation law, in the case when that law is satisfied only after the transformation, are discussed for Rosen's theory. For Logunov's theory the extended system of the gravitational field equations is similarly assumed to be satisfied by the metric only after the conformal transformation. The consequences of that assumption are investigated in the case of weak gravitational fields.

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INFLUENCE OF ION-ATOM IMPACT COMPLEXES ON DIFFERENT PROCESSES IN LOW TEMPERATURE WEAKLY IONIZED PLASMAS

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In low temperature plasmas very important rôle have processes where molecular ions are involved. As the first, such processes are fotodissociation processes influencing on the absorption continuum formation and dissociative electron-ion recombination processes, influencing on the excited atomic states population. A certain rôle have also molecular ion dissociation processes during electron-ion collisions. Besides molecular ions, in plasmas exist also corresponding ion-atom complexes. Under special conditions, such complexes may be interpreted as quasi-molecular ions with electronic states similar to electronic states of real molecular ions.

In this communication we demonstrate that in mentioned processes such complexes behave in a similar way as molecular ions, and consequently, must be taken into account in theoretical investigations and experimental data interpretation. Our discussion is based on the example of symmetrical and weakly unsymmetrical two atom systems (A_2^+ and AB^+, and: $A + A^+$ and $A + B^+$).

Our results indicate that processes with collisional complexes participation, play essential rôle in comparison with processes with molecular ion participation, in a wide range of conditions.

ELECTRON-IMPACT BROADENING ALONG HOMOLOGOUS SEQUENCE OF NOBLE GASES

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For the evaluation of physical conditions in stellar atmospheres as well as for abundance determination, the knowledge of the Stark broadening parameters for a large number of elements is of particular importance, as well as the study of similarities and systematic trends which may be used for various interpolations or critical evaluations of existing data.

One of the aims of this communications is to perform the first investigation of Stark broadening of Ar I, Kr I and Xe I lines on higher densities ($5.0 \times 10^{17} cm^{-3} \leq N_e \leq 1.62 \times 10^{18} cm^{-3}$) where is not available the experimental data for the lines examined. We performed also analysis of Stark broadening along homologous sequence Ar I, Kr I, Xe I in order to study regularities within a sequence of homologous atoms.

The plasmas in our experiment are produced in linear flashtubes filled with a noble gas at an initial pressure in the range 50 torrs to one atmosphere. Two spectrographs are used for the measurements of the light emitted: the first one having a low resolution for the continuum, the second one with a high spectral resolution for the line profiles.

An optical multichannel analyzer (O.M.A.II) is used for the light detection, standardization purposes, and for the mathematical treatment of the spectrum.

The electron density ($5.0 \times 10^{17} cm^{-3}$ - $1.62 \times 10^{18} cm^{-3}$) is obtained from continuum absolute measurements and from laser interferometry. The temperature (13000 - 18700 K) is obtained from the intensity of optically thick lines which is the case for strong lines in their centre. The normalized values:

$$W_N = W(10^{17}/N_e)(10^4/T)^{1/6} \text{ and } d_N = d(10^{17}/N_e)(10^4/T)^{1/6}$$

where W is the full width (FWHM) and d the shift are given in the Table 1.

Table 1.

Line	W_N(Å)	d_N(Å)	$W'_N(10^{-4}$ Å$^{-2})$	d_N
ArI 696.5 nm $(4s'[3/2]^o - 4p'[1/2])$	0.7	0.3	0.92	0.39
KrI 587.0 nm $(5s[3/2]^o - 5p'[3/2])$	0.6	0.23	1.13	0.41
XeI 473.4 nm $(6s[3/2]^o - 6p'[3/2])$	-	0.22	-	0.64

Using the modified semiempirical theory (Dimitrijević and Konjević, 1980; Dimitrijević and Kršljanin, 1986) as the starting point, we obtained for the sequence of homologous atoms the following expression:

$$W + id \approx A N_e T^{1/6} (0.487 - i1.299)\, F \qquad (1)$$

$$F = \Big\{\Big[(E_H - I_o + E_i)3(I_o - E_i)^2(E_s - E_i)^{1/2}\Big]^{2/3} + \\ + \Big[2(E_H - 4I_o + 4E_i)/3(I_o - E_i)^2(E_d - E_i)^{1/2}\Big]^{2/3}$$

Here, E_s, E_d and E_i are the energies of the (n+1)s', nd', and the initial level, respectively, E_H is the hydrogen ionization energy and I_o the ionization potential. Moreover, we have found empirically a linear relation $E_j = a + bI_o$, so that Eq.(1) depends only on the ionization potential and plasma conditions.

The normalized values

$$W'_N + id'_N = (W_N + id_N)/F\lambda^2$$

are given also in Table 1. A nearly constant ratio (within limits of ± 50%) indicates that Eq.(1) may be used for rough estimations of Stark broadening parameters in the considered case.

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INFLUENCE OF RADIATIVE PROCESSES ON GRAVITATIONAL INSTABILITY IN HOMOGENEOUS MAGNETIZED FLUID

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It is well known (Chandrasekhar 1961) that a self-gravitating fluid becomes unstable with respect to small perturbations if the related wave length exceeds certain value. In that case the gravitational force overpowers the pressure gradient and the instability sets in. This process clearly plays a basic role in the inital stage of a stallar cluster formation from fragmentation of interstellar matter.

In this work we investigate the influence of radiation on gravitational instability of a magnetized and perfectly electrically conducting fluid. Viscous effects are neglected while the thermal conductivity is taken into account. The medium is taken optically thick and the black body radiation condition is assumed.

The relevant linearized set of equations is as follows:

$$p = \rho_0 R T + R T_0 \rho \tag{1}$$

$$\frac{\partial \rho}{\partial t} + \rho_0 \nabla \cdot \vec{v} = 0 \tag{2}$$

$$\rho_0 \frac{\partial \vec{v}}{\partial t} = - R \rho_0 \frac{\partial T}{\partial z} - R T_0 \frac{\partial \rho}{\partial z} - \frac{4}{3} a_R T_0^3 \frac{\partial T}{\partial z} \vec{k} + \frac{1}{\mu_0} \nabla \times (\vec{B} \times \vec{B}_0) - \rho_0 \frac{\partial \varphi}{\partial z} \vec{k} \tag{3}$$

$$\frac{\partial \vec{B}}{\partial t} = \nabla \times (\vec{v} \times \vec{B}_0) \tag{4}$$

$$\nabla^2 \varphi = 4\pi G \rho \tag{5}$$

$$c_p^* \rho_0 \frac{\partial T}{\partial t} - 4 R R_p T_0 \frac{\partial \rho}{\partial t} = \frac{\partial p}{\partial t} + \varkappa^* \frac{\partial^2 T}{\partial z^2} \tag{6}$$

where the initial magnetic field is horizontal, along x-axis. Here: $c_p^* = C_p + 12RR_p$ is the effective specific heat, $\varkappa^* = \varkappa + 12RR_p \rho_0 D_r$ is the effective thermal conductivity, $R_p = p_r/p$ is the ratio of of two pressures, D_r is Roseland diffusion coefficient.

Assuming the perturbation scale lengths much smaller than the typical scale length for variation of unperturbed quantitities, we can treat the whole problem in a homogeneous medium. Perturbations are taken one dimensional and periodic in z-direction only.

When the Fourier-Laplace transform is applied to the set of equations (1)-(6), the following dispersion equation follows:

$$\omega^3 + iA\omega^2 + B\omega + iC = 0 \tag{7}$$

where:

$$A = -\frac{K^2 \varkappa^*}{\rho_0 (R - C_p)}, \quad B = \rho_0 4\pi G + K^2\left[\frac{R^2 T_0 (1+4R_p)^2}{C_v^*} - \frac{B_0^2}{\rho_0 \mu_0} - RT_0\right]$$

$$C = \varkappa^*\left[\frac{K^4 B_0^2}{\rho_0^2 \mu_0 C_v^*} - \frac{4\pi G K^2}{C_v^*} + \frac{K^4 R T_0}{\rho_0 C_v^*}\right]$$

The dispersion equation (7) yields the instability criteria and here we consider two special cases: I. Case with negligible heat conduction and II. Case with small heat conduction. The relevant instability criteria are

$$\text{II.} \quad \lambda > \left\{\frac{\pi}{\rho_0 G}\left[C_A^2 + \frac{C_S^2}{\gamma}\left(1 + \frac{R}{C_v^*}(1+4R_p)^2\right)\right]\right\}^{1/2}$$

$$\text{I.} \quad \lambda > \left\{\frac{\pi}{\rho_0 G}\left(C_A^2 + C_S^2\right)\right\}^{1/2} \tag{8}$$

where C_A is the Alfven speed, $c_v^* = c_p^* - R$, C_S is the sound speed.

Conclusions that follow from (8) indicate that the radiative pressure, as well as the magnetic pressure, stabilizes the instability while the diffusive process of the total heat conduction has the opposite effect.

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RESONANT EXCITATION OF MHD SURFACE WAVES BY STREAMING FLUID.

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It is well known that a localized surface MHD mode can exist and propagate along the boundary separating two fluids with different physical characteristics (Wentzel, 1979). Once created, these surface waves can transport energy in given direction of the discontinuity. If the boundary is not sharp, i.e. if it is taken as a narrow and continuous transition region, then a resonant mode conversion can occur at points where the relevant frequency matching conditions are satisfied. This process dissipates the surface wave energy into resonantly excited bulk waves (Hasegawa, 1982) which propagate away from the boundary. A finite transition region, however, also makes possible a resonant excitation of MHD surface waves by an external driver, a fluid flow in our case.

In this work we consider a perfectly electrically conducting fluid separated by the plane z=0 into two regions with different densities, ρ_1 resp. ρ_2. Let the fluid at $z \geq 0$ (Region 2.) move at speed $U_0(z)$, sharply changing from 0 at $z \leq 0$ to a stationary value U_0 at $z \geq a$. The flow takes place parallel to the boundary, along the x-axis, and also parallel to a homogeneous, stationary magnetic field H_0, permeating the whole space.

Starting from standard linearized MHD equations and applying the Bousinesq approximation we arrive at the following equation for the perpendicular perturbation velocity component w:

$$\frac{\partial}{\partial z}\left[\rho\,\epsilon(z)\frac{\partial}{\partial z}\frac{W}{\omega-K_xU_0}\right]-\frac{(K_x^2+K_y^2)}{\omega-K_xU_0}\rho\,\epsilon(z)\,W=0 \qquad (1)$$

where: $\epsilon(z)=(\omega-K_xU_0)^2-K_x^2V_{A2}^2$

Having solved the equation (1) for the three regions $z < 0$, $z > 0$ and $0 < z < a$ respectively and applying the appropriate boundary conditions at $z=0$ resp. $z=a$, we get the following dispersion relation:

$$D_0(\omega) + D_1(\omega) = 0 \qquad (2)$$

where:

$$D_0 = \varrho_1 \epsilon(0) + \varrho_2 \epsilon(a) \quad , \quad D_1 = \varrho_1 \epsilon(a) \epsilon(0) K \int_0^a \frac{dz}{\epsilon(z)}$$

We see that the first term in (2) alone gives the surface wave frequency spectrum while the additional term D_1, arising from the finite thickness of the boundary, gives a contribution to the instability growth rate at the resonant point z_r where $\epsilon(z_r) = 0$. The resonant condition $\epsilon(z_r) = 0$ in fact indicates the flow energy input into both the MHD surface wave and the bulk Alfven wave at the resonance.

The obtained instability differs from the standard Kelvin-Helmholtz instability which is also present in the case of a shear flow.

The described process is also important from astrophysical point of view as a mechanism for a wave turbulence generation by fluid motions in regions with discontinuities: solar coronal structures, solar wind interaction with the terrestrial magnetosphere etc.

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AN APPROXIMATIVE SOLUTION IN THE FRAME OF KINETIC NON-LTE APPROACH OF LYMAN α LINE TRANSFER IN CHROMOSPHERIC CONDITIONS

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The first completely self-consistent treatment of the non-LTE line transfer problem with convective transport of excited two-level atoms (ie. kinetic approach to non-LTE problem) was developed in the papers of Simonneau (1984) and Borsenberger et al. (1986a,b), by solving the two coupled kinetic equations for photons and excited atoms. Non-LTE line formation is, generally, characterized by three dimensionless parameters ε, ζ and η, measuring, respectively, the importance of inelastic, elastic collisions and streaming of excited atoms, which were taken, in previous papers, as the constants in constant property medium.

In this paper, we present a simplified solution of the two equations with depth variable parameters throughout the Solar chromospheric model (Vernazza, 1981) and for only one (central) frequency in Lyman α line. The behaviour of three parameters with optical depth in Lyman α is shown in Fig.1. Since $\zeta \ll 1$ throughout the entire model, elastic collisions have been neglected. The equations were solved using Feautrier technique applied to "two-fluid model" (Borsenberger et al., 1986).

As result, we obtained the behaviour of the source function in the chromospheric model (Fig.2.). As a consequence of the scattering effects, the line source function S shows a decrease outward and, finally, a drop at the surface to a value some 6-7 orders of magnitude below the local thermal one. At great depth S thermalizes to Planck value B. So, all main features of radiative transfer are clearly marked by this simple example.

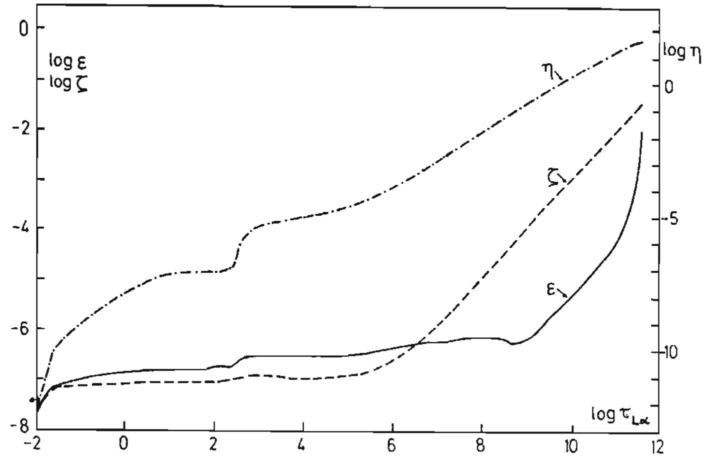

Fig.1. Parameters ε, ζ and η for Lyman α in Solar chromosphere.

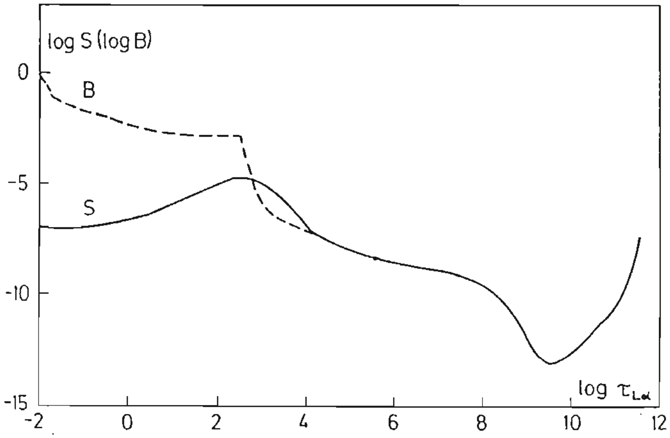

Fig.2. The source function S and Planck function B for Lyman α in the chromospheric model.

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VARIATIONS IN SOLAR CONSTANT

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The past decade brought us new understanding on solar and stellar sciences due to the accumulation of data from long series of ground-based measurements, and especially from space experiments (Skylab, OSO-8, NIMBUS-7/ERB, SMM/ACRIM, IUE, HEAO-2 (Einstein), Spacelab). All these new data enlarge immencely our knowledge on solar and stellar phenomena.

However, some new results shake our faith in one of the basic parameter of our star: stability of solar output. All indirect evidences about past terrestrial climate show high stability over last 8000 years (variation of mean temperature at midlatitude was about 3^{o} C).

Up to 1977. the best solar irradiance data over the visible spectral region have the absolute accuracy of the order of 10 %. Long-term variation (if any) should be less then 0.1 % per year. It is a nontrivial task for present day metrology to access such small variations over period of years. The requirement for absolute solar irradiance determination implies that measurements must be made from space. It was not possible until 1979. Now we have, for the first time, precise monitoring of solar irradiance from maximum to minimum of solar cicle. From 1980 till 1985 several indipendent satellite and high-altitude balloon experiments established a long-term steady downward trend of the average irradiance of 0.017 ± 0.003 % per year. Altrough space measurements have some disadvantages, (data are widely separated in time, need for intercalibrations, inhomogeneousness of independant data etc) nevertheless established monotonous downward trend seems to be real. The fading is however, too-fast for longer period of time. Such decrease could influence climate changes over the Earth. Several papers recently appear with excited ideas as: The Sun is fading out. Are we at the beginning of a new Ice Age? The Sun is expanding.

In this review, using the latest results, one attempt has been made to addres main problems of solar irradiance variability.

Short-term variations, visible as dips in recorded data, are due to sunspot blocking of convection by magnetic field. Storage and redistribution of missing flux is still an open question.

Activity cycle caused variations which are reconstructed from archived date from 1874, till 1981. Solar constant has 0.1 % lower values in maximum than in minimum. In the presented review it was pointed out that although some emission lines show great variation with activity cycles (CaIIK max/min $\approx$ 15 %, Lyman alpha max/min $\approx$ 75 %) their total contribution in bolometric luminosity is less 10^{-6}! This fact has been overlooked by some scientists.

Long-term changes in irradiance may be related to global changes in photospheric temperature, as recent experimental results do not suggest any solar diameter variations. A special attention has been drawn to deep photospheric line CI 538.0 nm which depth and equivalent width show no variation with activity but indicate a long-term decrease in effective temperature. Therefore, temperature and irradiance long-term decrease are consistent, indicating that the photosphere has got a slow varyng component. Sunspot number and area are not indexes for that.

SPECTRAL ANALYSIS OF A WHITE LIGHT FLARE

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We have studied the Stark effect and the continuum emission of a white light flare.

The flare started at 7 U.T. and ended at 8h45 U.T. The flare was observed close to the solar limb (N15, W75) on 26 - IX - 1963 at the Crimean Astrophysical Observatory using an eschelle spectrograph.

Stark effect. The line widths of Balmer series from H10 to H14 were measured on 7 spectrograms taken about 2 minutes apart. The width is very wide for the smaller quantum numbers and decreases to a minimum somewhere around H9 and then increases slowly to higher numbers. By assigning the Stark broadening to higher numbers we derive the values of the electron density.

From our analysis we confirm previous results that electron density from the line width is of the order of 10^{13} cm^{-3}. We also conclude that the electron density remained constant during our measurement (for 10 minutes).

Continuum emission. The continuum emission was analysed by a photometric determination of the contrast $\Delta I(\lambda) / Io(\lambda)$ in the wavelength range 3700 - 4300 A.

The possible mechanisms for the emission were investigated, namely hydrogen Paschen and H^- continua. We show that H^- is unlikely and derive strog constraints on the temperature structure and energy deposition mechanism imposed by the Paschen continuum process.

The site where the continuum emission was formed must be in the chromosphere where the temperature was between 12000 and 14000 K.

We normalized the ratio $\Delta I(\lambda) / Io(\lambda)$ for 5 spectra to the corresponding ratio at a reference wavelength, λr,

$$R(\lambda, \lambda_r) = \frac{\Delta I(\lambda)}{I_o(\lambda)} \bigg/ \frac{\Delta I(\lambda_r)}{I_o(\lambda_r)}$$

where λ_r = 5000 Å. We note that between each of the 5 spectra there was no great difference between the corresponding R (λ, λ_r) curves.

These conclusions are reached by comparison of the experimental curves with theoretical ones.

A MANUAL SOLAR SPECTRUM SCANNER

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The need for various research programs at Belgrade equaorial solar spectrograph motivated the construction of a specific spectrum scanner.

It is a photoelectric scanner based on a 1P21 photomultiplier as the radiation receiver. The scanning principle is well known: the rotation of a tipping glass. In this case it is a 17-mm glass cube located in front of an exit slit in the focal plane of the spectrograph. The cube rotates for ± $40^{o}$to each side of its mean position. The axis of rotation is parallel to the spectral lines. An analog angle encoder (actually an one-wire potentiometer) at the same rotation axis provides the X-coordinate electrical signal for an X-Y recorder where the photomultiplier signal is recorded along the Y-coordinate. The recording is independent of time and the scanning speed can be to a considerable extent variable. During the experimental stage the scanning is being done manually.

The access of a digital angle encoder to the rotation axis is provided. However, for the begining, the digitalization of complete analog records is envisaged on the basis of a Mini-MOP digitalizer at the Belgrade Faculty of Sciences.

Besides digitalization, the usual reduction of the recorded data includes the following steps:

1. Dark current reduction. It is done by proper translation of coordinate system at the digitalizer.

2. Flat field reduction. For this purpose a laboratory continuous spectrum is recorded and the necessary coefficients for corrections of systematically different light-losses at various angles of the tipping glas are obtained.

3. Normalization to the continuum level. A suitable wavelength interval near the observed spectral line, not more than one nanometer apart, is chosen and its level taken as the intensity unit.

4. Correction of the X-scale. An empirical relation of various tipping glass positions (angles) and the corresponding spectral line scanning shifts is found. With the known linear dispersion the calibration of the X-scale at the recorder is done. At this stage, it is taken as independent of time.

5. Reduction of the instrumental profile. So far, the instrumental profile has been determined by means of selected telluric lines (red spectral region). Preparations are in progress to evaluate it in the middle visual wavelengths.

6. Scattered light correction. The atmospheric and imaging instrumental scattered light is negligible. A contribution of non-selective light diffusion in front of the exit slit has not been determined yet.

7. Spectrophotometric measurements. As all the measured X and Y data are introduced into a computer, the desired spectrophotometric quantities are calculated automatically.

GAUSSIAN DISTRIBUTION AND TWENTY TWO YEAR CYCLE OF SUNSPOTS

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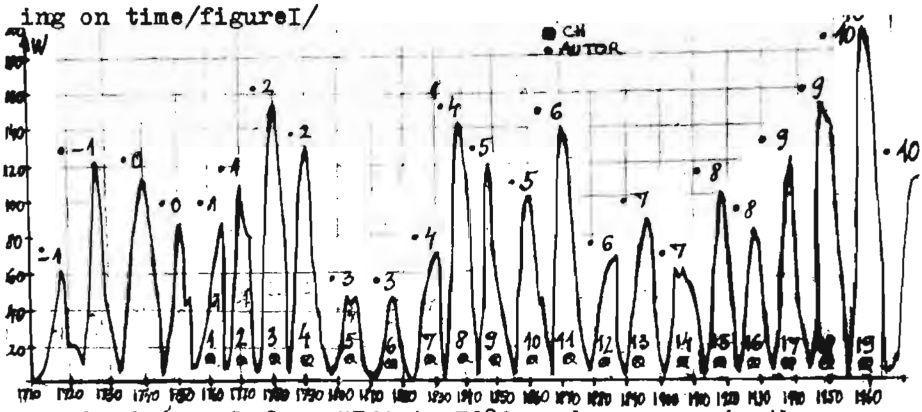
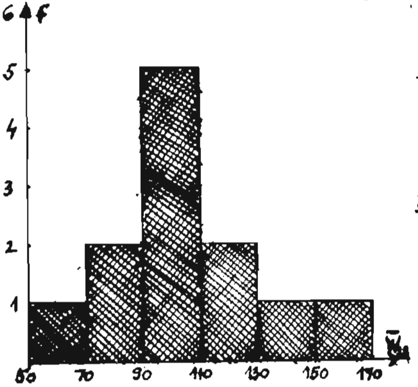
Sanspots are the best, clearly visible, indikators that determine the intensity of the sum activity.They were also observed in the ancient times when the only instrument for observing celestial bodies was an eye.Due to the fact that a relatively wide range of information about the solar activity can be obtained from them ,sanspots are used indirectly for the study of the solar activity mechanism itself.

On the basis of the change of Wolf's number /W/depending on time/figureI/ in the interval from I7I0 to I980,we have come to the following conclusions: A 22-year cycle of the solar activity is taben to form the so-called mean Wolf's number for 22 years/$\overline{W}_{22}$/, as the sun of the maximum values of two consecutive 11-year cycles divided by 2: $\overline{W}_{22} = \frac{W_{11}^{I\,MAX}+W_{11}^{II\,MAX}}{2}$



$\overline{W}_{22}$ is put on the abscissa of figure2 and the frequency of the occurence of a particular maximum value of a 22-year cycle of the solar activity-on the ordinate.



t	-1	0	1	2	3	4	5	6	7	8	9	10	
$\overline{W}_{22}$	92	96	96	144	51	100	112	102	75	89	129	151	

INTERVAL	50-70	70-90	90-110	110-130	130-150	150-170
$\overline{W}_{22}$	51	75 89	92 96 96,100 102	112 129	144	151
f	1	2	5	2	1	1

FIGUREII (dII)

Lets mark it with f and call it frequency. The graph shows a histogram which conforms with a Gaussian distribution, or rather tends to approximate it/dII/. The tables beside the histogram give a more detailed representation of how $\overline{W}_{22}$ and f are obtained. A 22-year cycle of the solar activity has been taken as a physical characteristic of the sun, for in that interval the polarity of sunspots is changed. It is interesting to observe that if the method in question is applied to such two consecutive 11-year cycles that the first one has the leading spots in the northern hemisphere marked with the sign/-/or/S/and the second/+/or/N/, it does not result in a Gaussian distribution. It is necessary to point out that the observed interval of sunspots cycles is relatively small for study of stellar processes of this kind, but it can be taken as a sample for these periods of the solar activity which have no extreme minimums or maximums/such as Maunder's minimum/.

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BEGINING OF A STUDY OF LONG-TERM CHANGES OF SELECTED FRAUNHOFER SPECTRAL LINES

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A number of Fraunhofer lines are known to change some of line-profile characteristics in time as well as accross the solar disk. There is possibility of finding their long-periodic changes with the solar activity cycle. The measurements of the depth, half-width and equivalent width of some selected lines has been started at Belgrade Astronomical Observatory with the solar spectrograph and its new scanner. The integral light of the solar disk is used in order to be close to the usual approach in similar stellar activity studies. The program is aimed to last at least through one 11-year cycle.

The lines to be observed, Table I, are selected according to some indications or expectations of their variability and to the possibility to obtain their profiles by the spectrograph. At the short wavelengths the sample is cut by the convenience of finding a certain line and at the long wavelengths the photomultiplier sensitivity decreases. Various values of exitation potential, E_p, Lande factor, g, and photospheric levels of formation of spectral lines are included in this sample. The equivalent widths, W, are selected within the values that can be measured with higher certainty. This is still a preliminary or working list.

Table I

Element	Wavelength (nm)	W (pm)	E_p (eV)	g	Remarks
Mg I	518.36	158.4	2.72	-	Line depth only
Fe II	519.76	8.0	3.23	0.7	
Cr II	523.73	4.9	4.07	-	
Sc II	523.98	5.5	1.45	-	
Fe I	525.02	6.2	0.12	3.0	
Ca I	526.17	9.9	2.52	-	
Fe I	530.74	8.6	1.61	-	Weak CrI in the wing
Ti II	533.68	7.1	1.58	-	
Mn I	539.47	7.4	0.00	-	Doublet
Fe I	539.83	7.6	4.44	0.3	
Fe II	542.43	4.8	3.20	-	
Fe I	543.45	18.4	1.01	0.0	Distant continuum
Fe I	550.68	12.0	0.99	2.0	
Sc II	552.68	7.6	1.77	1.0	
Fe I	557.61	11.3	3.43	0.0	
Ca I	558.19	9.1	2.52	1.5	
Ca I	560.13	10.0	2.52	-	
Na I	568.26	10.4	2.10	-	
Na I	568.82	12.1	2.10	-	Doublet
Fe I	569.15	3.8	4.3	0.0	Blended with NiI, E_p=4.1

It is expected that at least some of these lines will show certain long-term changes.

INFLUENCE OF STARK BROADENING ON EQUIVALENT WIDTHS OF Si II VISIBLE LINES IN STELLAR ATMOSPHERES

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Because of its large cosmical abundance, the silicon is of special importance in solar and stellar studies. For stars with effective temperature from 10000 to 20000 K (A0 to B3) the Si II spectrum is dominant, with strong lines in the visible, as well as in the UV where occure the resonance multiplets. In particular the Ap Si stars spectra reveal many Si II lines of high excitation, such as those of the 4d-nf series which are very sensitive to the plasma broadening effects. In this paper the Stark broadening of visible Si II lines is studied and its consequence on the intensity of the stellar absorption is analyzed. A complete set of atomic data concerning the Stark widths is elaborated for 19 multiplets of Si II of astrophysical importance (T.Lanz et al, 1987). Previous available determinations are rewieved and new Stark widths are calculated by means of the semiclassical impact theory (Sahal-Bréchot, 1969a,b).

The new adopted Stark widths are given in Table.

Table: Stark full halfwidths of 4d-nf Si II lines at $N_e=10^{17}cm^{-3}$.

Line (Å) (Mult.)	T=5000 K	10000 K	20000 K	40000 K
4621. (7.05)	22.8	23.3	24.0	24.0
4201. (7.06)	32.3	34.5	36.5	36.8
3955. (7.07)	48.9	52.6	55.8	56.0

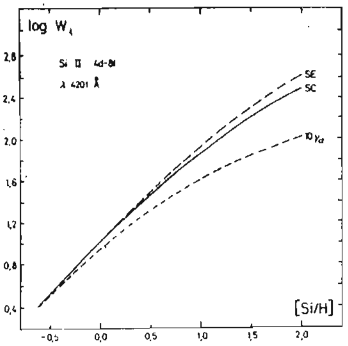

Fig. 1: Theoretical curves of growth of the 4201 Å Multiplet with different estimates of its Stark width ($10\,\gamma_{cl}$, SC and MSE) for T=10000 K.

These results were applied in several examples to the analysis of stellar absorption lines. Theoretical curves of growth of the λ 4201 Å multiplet with new Stark width data (SC curve) and Stark width calculated using the modified semiempirical theory (Dimitrijević and Konjević, 1981) are compared in Fig. 1 with data obtained using ten times the "classical" damping value (ie $10\gamma_{cl}$).

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CONSTRAINED DECONVOLUTION

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The benefits of physical-realizability constraints in the problem of deconvolution are nowadays well recognized.

When comparing different deconvolution methods their fundamental properties should be compared:

a) Quantity of a priori information that could be implemented. For all correctly founded methods this property determines the quality of deconvolution.

b) Speed, that determines the quantity of data that could be processed in the unity of time.

c) Availability of a priori information used in the method. That information could be easily or hardly obtained, more or less reliably, so this property influences both a) and b). In this sense, general a priori information as positivity, smoothnes, band limitation etc. is more desirable.

d) Accomodability of the method. There is a number of deconvolution methods developed for the intended purpose. These methods works best for the intended purpose. But it is very desirable if a method could be accomodated for the different problems that cold arise.

A deconvolution method constrained to produce only physically realizable solutions, intended to satisfy all the properties listed above is presented in this comunication.

Spectroscopic application is demonstrated.

The spectrometer completely obliterates the information at all Fourier frequencies beyond some finite cutoff. This is specifically true for dispersive optical spectrometers where the aperture determines cutoff.

Similar considerations prevail in Fourier interferometer, where the cutoff is determined by the maximum path difference.

Physical constraints are applied by correcting the components of the signal in the Fourier space.

INDIRECT STELLAR IMAGING
FROM SPECTROSCOPIC AND PHOTOMETRIC OBSERVATIONS

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A technique for reconstructing surface brightness distributions on stars from high quality (signal to niose ratio and resolution) spectroscopic and photometric observations is described. A technique is based on rotational modulation of rotationally-broadened absorption line profiles and photometric light curves. The methods of image reconstruction from projections are developed for this purpose.

The image reconstruction algorithm should be determined by real observational constraints. The precision of the projection is limited by actual signal to noise ratio and image resolution is limited by spectral and temporal resolution. For this purpose two kinds of image pixels (resolution and projection pixels) are introduced.

Due to the very ill-conditioned nature of this image reconstruction problem, the regularization of the reconstruction should be done. A choice of the specific regularization method depends of the a priori information that is available. Thus the quality of the reconstruction (reality of solutions and image resolution) depends on the a priori information available as well as of the quality of observations (signal to noise ratio, spectral resolution and phase coverage density).

The origins of the ill-conditioning of the problem are disscused as well as regularization methods that should be applied.

The methods, using Doppler imaging technique are illustrated.

For the given surface brightness inhomogenities that produces spectral variability the synthetic spectrums were calculated.

En example of the physically unconstrained (no a priori information) minimum norm reconstruction is shown.

In the cetrain cases (if there are only spots on the stellar surface) the Maximum Entropy Method could be applied. Due to the strong regularization properties of this method better reconstructions are expected.

ON NEUTRAL OXYGEN LINES FORMATION IN γ CAS

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Two intense infrared triplets of neutral oxygen ($2p^3\ 4s\ ^3S^o_1 - 2p^3\ 3p\ ^3P_{0,1,2}$, λ = 13165 Å and $2p^3\ 3d\ ^3D_{1,2,3} - 2p^3\ 3p\ ^3P_{0,1,2}$, λ = 11287 Å) have been recently observed in the emission spectrum of the Be type star γ Cas (Chalabaev, 1984) with the Canada - France - Hawai 3 m 60 telescope. Both multiplets have the same lower term $3p\ ^3P$.

In order to investigate the formation of O I lines observed in the infrared spectrum of γ Cas, the following processes have been considered for populating the $4s\ ^3S^o_1$ level:

- $2p^4\ ^3P - 2p^3\ 3d\ ^3D^o$ photoexcitation by Ly β
- $2p^4\ ^3P - 2p^3\ 4d\ ^3D^o$ photoexcitation by Ly γ followed by cascades towards $4s\ ^3S^o$ (4d - 4p - 4s).
- $3d\ ^3D^o - 4p\ ^3P$ collisional excitation transfer by electrons and protons followed by cascades towards $4s\ ^3S^o_1$.
- $3d\ ^3D^o - 4s\ ^3S^o_1$ direct collisional excitation transfer by electrons and protons.

The results of our analysis, using the model of Poeckert and Marlborough (1978) for the γ Cas envelope model indicate that the considered lines are formed in the initial part of the envelope and that the collisional coupling $3d\ ^3D^o - 4p\ ^3P - 4s\ ^3S^o_1$ is predominant for populating the $4s\ ^3S^o_1$ level.

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CLOSE BINARY SYSTEMS WITH ACCRETION DISK

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The possibility to determine from the curve of luminosity analysis, parameters of close binary systems with accretion disk is considered in this communication. The system's model, giving the synthetic curve of luminosity has been made. This result gives possibility to determine parameters of the system using the developped inverse problem method. In this communication, the model of system, the inverse problem method, as well as the short analysis of results are presented.

THE CHEMICAL COMPOSITION OF THE GALILEIAN SATELLITES

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The chemical composition of celestical bodies can be determined either by remote spectroscopy or within theories attempting to explain their origin and internal structure.According to recent reviews (Encrenaz,1984;Stevenson,1985;Zellner et al.,1985),our knowledge of the chemical composition of the smaller bodies of the solar system is rather limited.

The aim of this paper is to determine theoretically the chemical composition of the Galileian satellites.All the calculations have been performed within the theory of behaviour of materials under high pressure,proposed by P.Savić and R.Kašanin (Savić and Kašanin 1962/65;Čelebonović,1986;Savić and Teleki,1986 and references given there).This study has been undertaken with the idea of testing the applicability of the theory to planetary satellites and,in case of satisfactory agreement, extending it to the determination of the composition of the asteroids.

As input data we have used the masses and radii of the satellites (Masson,1984).The results are presented in the following table,in which A denotes the mean molecular weight of mixtures which can approximate the composition of different satellites.

SATELLITE	A	MIXTURE
Io	70	22%$FeSiO_3$ + 20%FeS + 28%SO_2 + 30%$N_2H_4H_2O$
Europa	71	
Ganymede	18	85%SiO_2 + 7%H_2O + 8%H_2
Callisto	19	

A detailed comparison of our results with observational data (Dollfus,1975;Masson,1984 and many other references) reveals that the mixtures by which we have described the composition of the satellites contain most of the actually observed elements.

As for the origin of the distribution of values of A shown in the table,it can be explaind by the depletition of the inner parts of the circum-jovian accretion disk in light elements,due to the excess luminosity of proto-jupiter (Graboske et al.,1975; Masson,1984).

In conclusion,it has been shown that the theory proposed by Savić and Kašanin can be used in studies of planetary satellites, and that it seems reasonable to attempt using it in studies of asteroids.

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ASTROPHYSICS IN THE NINETEENTH CENTURY SERBIAN LITERATURE

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The first Serb to mention astrophysical instruments and methods was Atanasije Stojković in his <u>Physics</u> (18o1-18o3). They are next spoken of by V. Marinković in 1851.

The dilemma as to whether our Sun was an incandescent or a dark body was shared by the Serbian authors of the day. In 1783 Z. Orfelin wrote that Sun was a fiery and dense body whereas A. Stojković adopted some newly-appeared interpretations and claimed it was dark. The works of his contemporaries P. Solarić (18o4) and G. Lazić (1822) are in the same vein. Along with some others - including V. Varinković in 1851, they adhere to the views propounded by W. Herschel and other foreign astronomers. G. Popović, however, questioned this view in 185o and the theory of the dark sun was completely abandoned in the latter half of the century when the debate focused on its chemical composition, energy and how it is sustained and Sun's "life-span". The subject of interest of Dj. Stanojević was the solar nature and he published some works about it in France. He also went to Siberia to watch the solar eclipse in 1887.

The moon was written about much less. The attention was drawn to its surface and its possible changes. A. Stojković referred to its volcanoes also seen by W. Herschel. Most authors believed the existence of water and air on the moon impossible.

Information about the planets is largely found in calendars announcing invariable the ruling planet of the year, with often lengthy articles about it, based on the then knowledge about its size, movement, appearance, physical properties, spectrum and atmosphere.

The first authors peaking of comets dwell mostly on their descriptions and paths. At a somewhat later date more attention is attached to their nature, composition, whether they glow with their own light or reflect it. Yet, in 1888 M. Andonović admitted that very little was known about the comets' physical properties. There is also information about the disintegration of comets and origin of meteorite swarms.

The notorious doubts regarding the origin of meteor phenomena found their reflection in the works of Serbian authors. Chladni's view was known to V. Bulić who, in 1824, explained the falling stars as a product of particle ignition due to the electricity of the air or some unknown chemical reaction. V. Marinković tackled them also saying that the falling stars were small bodies revolving around Sun, which could fall on Earth because of the force of gravity. Bolides are larger bodies which can fall as stones of different chemical composition. Two rather large meteorite had fallen in Serbia and scientific papers about them were published by J. Pančić, S. Lozanić, J. Žujović and A. Stanojević in 188o,189o and 1891. The public wanted know about life in the outer space and the papers included information about the organic matter found in the meteorites.

The physical properties of the stars were not mentioned until the latter half of the 19th century. V.Marinković wrote about variable and new stars, and Dj. Stanojević about Secchi's division of the spectrum in 4 classes. More about stars can be found in M. Andonović:their spectra, atmospheres, composition, old and young stars. J. Mihailović wrote about star temperatures, their differences and variations in 1895-96.

Information about the Milky Way and nebulae was scant. Some mention can be found in V. Marinković saying that a nebula branches out as the Milky Way. It is also noted that one hundred nebulae were known before Herschel and that he discovered about 25oo of them. Some authors distinguish resolvable, semiresolvable and irresolvable nebulae.

The above shows that most of the relevant astrophysical phenomena were written about but in a popular way, accessible to pupils and readers of average education.

ON THE ASTRONOMY TEXTBOOKS AND THEIR REPRESENTATION OF CONTEMPORARY SCIENCE

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Report on last 25 astronomical years. Problems of the reflection of the present scientific moment on educational literature have been considered and systematic analysis of scientific methods and procedures and their adaptation to different educational levels has been postulated. Typical tematic distribution of general astronomy textbooks in our country and in the world since 1962 up to now, was presented. One point out on the digestion of scientific papers and reviews and on their contents classification.

One establish the value of a complex problem exercise as the closest reflection of the scientific method. Further, the rôle of new computer helping devices in education, and different forms of educational technology has been considered. The virtual existence of modern Yougoslav terminology was established as a critical moment in the educational literature. Moreover, the urgent need for the terminology and dictionary elaboration, primarily on the basis of M.sc. and Ph.d theses was pointed out.

DEVELOPEMENT OF AMATEUR RADIO ASTRONOMY AS AN IMPROVEMENT OF ACTIVITY OF ASTRONOMICAL SOCIETY AND PEOPLE´S OBSERVATORY

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Intensive developement of electronics in last years, made possible that astronomical societies, and even individuals can provide with professional electronic equipements. Consequently, by using modern radioamateur receivers, used up military devices and similar, by adaptation and selfconstruction of corresponding structures, by construction of special antenna systems and so on, one can obtain a reliable radio telescope with a modest financial source.

Besides the improvement of activities, developement of radio astronomy attract to astronomical societies attention of individuals interested for other scientific disciplines as radio technique, electronics, automatics, computer science etc.

Education of skilled workers and developement of radio astronomy equipements is the first stage for data receiving from scientific satellites, orbital telescopes et similar.

SOME CHARACTERISTICS OF THE SKY BRIGHTNESS IN BELGRADE

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Narodna opservatorija, Kalemegdan, 11000 Beograd

The sky brightness over Narodna opservatorija was determined with original photographic procedure. On the series of photos were derived some other characteristics of astro-climate too.

ON THE PHOTOGRAPHIC OBSERVATION OF DOUBLE STARS

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The possibility of optimal treatment by photographical observation of the double stars will be considered.

ON THE PHOTOGRAPHIC DETERMINATION OF LUNAR LIBRATIONS

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The processing of determination of the Lunar librations from photos was hurried with some modifications. The accuracy of the method was analyzed. The determination of possible physical libration for the Belgrade and Sarajevo photos will be discussed.

THE LIMITING STELLAR MAGNITUDE OF THE SARAJEVO SKY ATLAS

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Stellar fields with star clusters - the photographic standards were analyzed. The limiting stellar magnitude in blue and red colour was determined. Corresponding the determined values on theoretical formulas are derived some parameters of astro - climate.

PHOTOELECTRIC PHOTOMETRIC OF ECLIPSING BINARY STARS

Aleš Dolžan

Zasavska 88, 61231 Ljubljana Črnuče

Method of observing with 0.3 m Cassegrain telescope and photoelectric photometer is described. Reduction to standard Johnson system and transformation coefficients is presented. Results of observations of eclipsing variables are shown - times of minima, heliocentric correction, O - C and complete light curve of W UMa and 44 Boo.

PHOTOGRAPHY OF SUPERNOVA 1987A

Aleš Dolžan

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Photography of supernova 1987A in Great Magellan Cloud made in South America – Peru is shown. Magnitude and color index estimation from photographic photometry are presented.

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DEUXIÈME COLLOQUE
SUR
LA DYNAMIQUE
DES IONS,
DES ATOMES
ET DES MOLÉCULES

BOURGES, 1-3 septembre 1993

STARK BROADENING OF Zn II AND Cd II LINES WITHIN THE MODIFIED SEMIEMPIRICAL APPROACH

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Stark broadening data for singly charged zinc and cadmium ion lines are of interest for analysis of hot star spectra (see e.g. Sadakane *et al.* 1988, Danezis *et al.* 1991, etc.) and laboratory plasma.

Stark broadening data of Zn II and Cd II lines have been measured by Kusch & Oberschelp (1967), and Djeniže *et al.* (1991).

We have calculated Stark full widths (FWHM) and shifts for several Zn II and Cd II spectral lines by using the modified semiempirical approach (Dimitrijević & Konjević 1980, Dimitrijević & Kršljanin 1986) for an electron density of 10^{23} m^{-3} and temperatures from 5,000 up to 50,000 K. Atomic energy levels needed for calculations have been taken from Moore (1971). Oscillator strengths from Wiese & Martin (1980) for Zn II and from Kunisz *et al.* (1975) for Cd II lines have been used when available. Otherwise Coulomb approximation (Bates & Damgaard 1949) has been applied. The multiplets are selected according to their astrophysical importance (Sadakane et *al.* 1988; Danezis *et al.* 1991) and according to the available experimental data (Djeniže et *al.* 1991, Kusch & Oberschelp 1967).

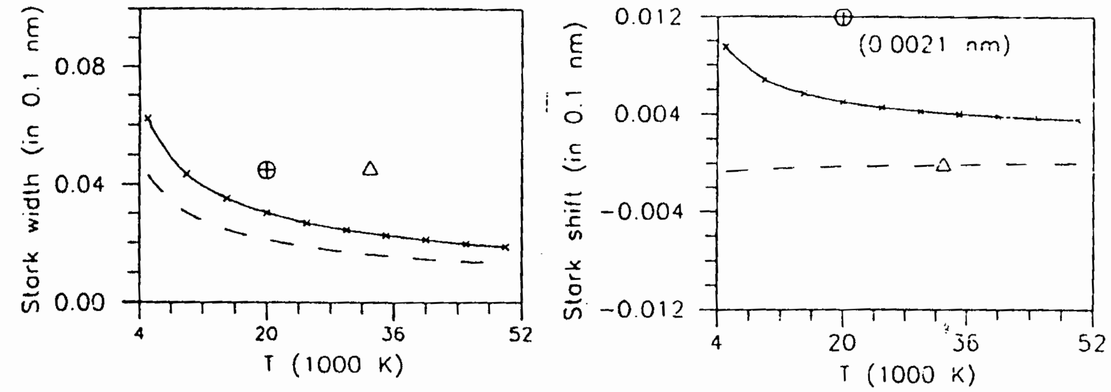

Fig. 1. *Stark full width (a) and shift (b) for the Zn II 206.20 nm* $(4s^2S_{1/2} - 4p^2P^0_{1/2})$ *spectral line as a function of temperature (T), at electron density of* $N=10^{23}$ m^{-3}*. The used notations are: (—) present results calculated by using the modified semiepirical method (Dimitrijević & Konjević 1980) with oscillator strengths by Kunisz et al. (1975) when available, (-×-×) present results with oscillator strengths by Wiese & Martin (1980) when available, (- - -) present results with Coulomb approximation only for oscillator strengths. Experimental data: (△) Djeniže et al. (1991), (□) Kusch & Oberschelp (1967); (⊕) the estimate of Lakićević (1983).*

In Figs. 1ab. and 2ab. our results for Stark widths and shifts of Zn II and Cd II resonant spectral lines have been compared with available experimental data (Kusch & Oberschelp 1967; Djeniže *et al.* 1991) and with simple estimates (Lakićević 1983) based on regularities examination. Taking into account the com-

(Lakićević 1983) based on regularities examination. Taking into account the complexity of radiators and the fact that calculated shifts are of less accuracy than widths (see e.g. Dimitrijević *et al.* 1981) when they are much less than widths (Wiese & Konjević 1992) as in the present case, the presented ratios of experimental to theoretical shifts are of much less importance and are given here only for completeness.

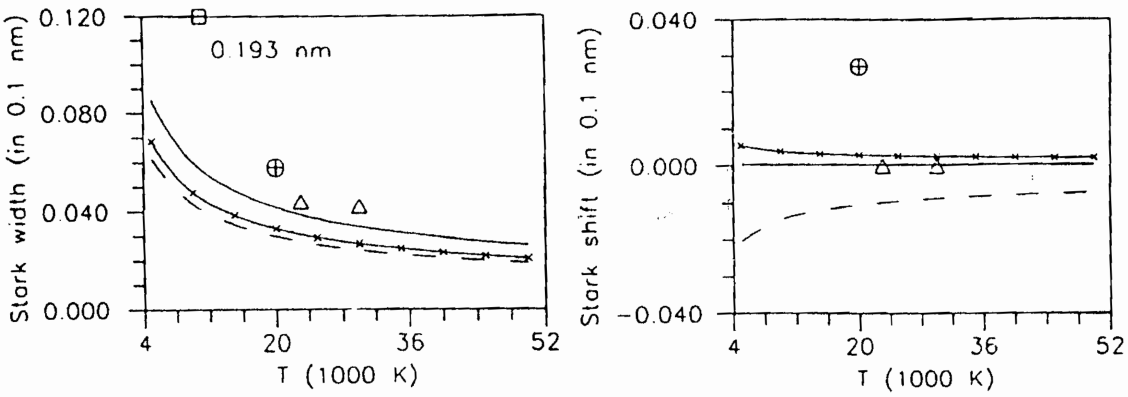

Fig. 2. *As in Fig. 1, but for Cd II spectral line* $\lambda = 226.5$ *nm* $(5s^2S_{1/2} - 5p^2P_{1/2})$.

In Figs. 1ab and 2ab we can see that the obtained differences in Stark broadening parameters are within the error bars of the method, but in the case of the shift the accuracy of oscillator strengths may be very important. This is well illustrated in Fig. 2b. where even the sign of shift is different for two different oscillator strength sets. We can conclude that shifts are more sensitive to the oscillator strength accuracy than widths.

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EUROPEAN ASTRONOMICAL SOCIETY

2ND GENERAL MEETING

EXTRAGALACTIC ASTRONOMY AND OBSERVATIONAL COSMOLOGY

under the high patronage of

Mr. Lech Wałęsa
The President of Poland

The Nicolaus Copernicus University

Toruń, Poland

18 - 21 August 1993

of ionization associated with star formation. It is important to have observations on all angular scales to distinguish between theoretical models.

Observing programmes are in progress with sensitivity approaching $\frac{\Delta T}{T} \sim 10^{-5}$. A major challenge is to distinguish between foreground emission from the Galaxy and the CMB. This requires careful comparison of observations made at a range of wavelengths but with the same observing beamshape. Signals arising from synchrotron, free-free and thermal dust emission are detected in the various programmes. Detections of intrinsic CMB fluctuation are being claimed by observers, some on a statistical basis only (such as the COBE result) and others as direct observations of structure (as in the Tenerife data). The status of these reports will be discussed in the lecture.

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31. On the Stark-Broadening of Solar and Stellar Pd I Lines

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Neutral palladium lines are present in solar spectrum where fifteen lines of this element have been identified (Moore *et al.* 1966; Biémont *et al.* 1982). The development of satellite astronomy providing high resolution spectrograms, gives possibility to determine palladium abundance in stellar atmospheres as well. Recently, Orlov and Shavrina (1991) have analyzed Pd I lines existing in stellar spectra and particularly 14 Pd I lines observed in the Procyon (α CMi) spectrum. They have shown that the only line suitable for determining palladium abundance in stellar atmospheres is Pd I 3242.70 A line. Since α CMi is rather hot star with $T = 6750$ K and $\log g = 4.0$, and since the all sky survey by the means of satellite astronomy should provide high resolution spectra for other hot stars with non negligible electron-impact influence on spectral line shapes (e.g. hot white dwarfs), it is of interest to provide corresponding Stark broadening data enabling to perform better determination of palladium abundance. In order to provide such data we have calculated electron-, proton-, and ionized-helium-impact line widths and shifts for 3 Pd I multiplets by using the semiclassical-perturbation formalism. A summary of the method is given in Dimitrijevič *et al.* (1991). We hope that the present results will make a better determination of palladium stellar abundances possible, especially in the case of white dwarfs and stars of A and B type.

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were in UBVRI filters accordingly: 1.36; 0.98; 0.53; 0.51; 0.44 (in magn). Colour indices approximately followed variations of the light curve and indicated the common tendency of the galaxy to become blue with brightening.

Dependencies between magnitudes in different filters as well as magnitudes – colour indices are well expressed, but observational data obtained during the season 1990–1991 showed colour anomalies in the galaxy behaviour. This fact also reflected two-colour diagrams of NGC 4151: the tendency to become blue with brightening was decelerating.

The NGC 1275 galaxy (type Sy2 or BL Lac) long photometric minimum has been continuing since the end of 70-ties and only small brightness fluctuations are observed. Behaviour of its colour indices seems to be the same.

Dependencies between magnitudes and colour indices for NGC 1275 expressed worse because of small colour variations and big scatter of data exceeded observational errors. Complicated and asynchronous changes of colour indices of NGC 1275 variable nucleus both in ultraviolet and red spectral regions permit us to suppose two variable sources in the nucleus.

By analysis of NGC 1275 galaxy light curves within one night we are discovered rapid flares of two types. Type I flares are characterized by maximum increasing or decreasing of flux in U-filter meanwhile minimum changes have taken place in filter I (i.e. the amplitude of event is increased with the frequency similar to flicker noise). During the flare of type II flux increasing in I-filter is accompanied by constant flux in U-filter (within limits of observational errors) or even by its decreasing at 3 – 4 %. Maxima amplitudes of observed flares were 5 – 15 %, their durations were 15 – 30 minutes.

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95. Excited Helium Atom States Population Due to Electron-Ion-Atom Recombination

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We present results of the study of population of helium atom excited due to recombination processes $\mathrm{He} + \mathrm{He}^+ + e \rightarrow \mathrm{He} + \mathrm{He}^*(n)$ in weakly ionized helium plasma. These processes have been compared with known processes of dissociative recombination $\mathrm{He}_2^+ + e \rightarrow \mathrm{He} + \mathrm{He}^*(n)$ and it has been shown that both processes must be taken into account simultaneously, since their contributions are comparable. The inverse process of ionization has also been studied in detail. A simple method for the calculation of the corresponding rate coefficients is presented.

The presented method offers a possibility for the determination of the relative participation of the considered processes and for the calculation of the corresponding rate coefficients in general case. The investigation of such reactions is of interest for helium rich star plasma research (Mihajlov and Dimitrijević, 1992).

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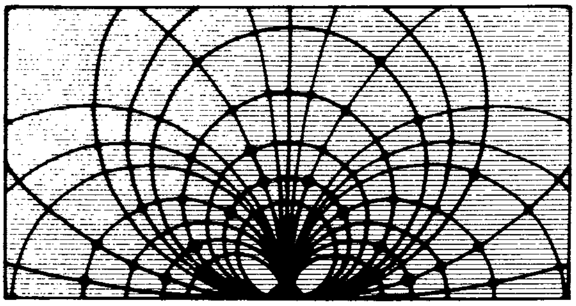

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Book of Abstracts

FREE UNIVERSITY, AMSTERDAM, THE NETHERLANDS
APRIL 15-19, 1985
Editors: A.E. de Vries, M.J. van der Wiel

ELECTRON IMPACT BROADENING DEPENDENCE ON THE IONIZATION POTENTIAL: $np^{k-1}(n+1)s-np^k$ RESONANCE TRANSITIONS

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INTRODUCTION

A method for a simple estimate of electron impact broadening parameters may be useful for a number of physical and astrophysical problems. It was demonstrated recently/1/, that the electron impact width ω and the shift δ (in units of angular frequency) of spectral lines emitted by a non-hydrogenic atom (or ion) depend on the "effective ionization energy" $I=I_0-E_\ell$ (I_0 and E_ℓ denote the ionization potential and the energy of the lower level, both counted from the ground level) in the general form of a power series:

$$\omega = \sum_k A_k' I^{-k} \text{ and } \delta = \sum_k B_k' I^{-k} \qquad (1a,b)$$

After calculating coefficients in Eqs.(1) and averaging them over a number of elements, it was found that /1/ for particular plasma conditions $N_e=10^{17}$ cm^{-3} and T=20000K, for the resonance lines of singly charged ions, half halfwidth w and shift d in wavelength units can be expressed as

$$w \approx 2050\ I^{-4}(\text{Å}) \text{ and } d \approx 2050\ I^{-4}(\text{Å}) \qquad (2)$$

where I has to be taken in eV.

Here, we want to study the relation between the electron impact widths and shifts of singly charged ion resonances (for $np^{k-1}(n+1)s-np^k$ transitions) and the ionization potential.

RESULTS AND DISCUSSION

At temperatures lower than or equal to 20000K, the successful approximation for resonance transitions in consideration is the low temperature limit form of the semiempirical approach /2/, modified in order to take into account the existence of k equivalent electrons:

$$\omega = 8(\pi/3)^{3/2}(\hbar a_0/m)N_e(E_H/kT)^{1/2}\Big[\langle i|(r/a_0)^2|i\rangle \bar{g}_{th} + \sum_{L_c} k\langle p^k\{|p^{k-1}\rangle^2 \langle i|(r/a_0)^2|f\rangle \bar{g}_{th} + |\langle i|\frac{\vec{r}}{a_0}|f\rangle|^2 (k\langle p^k\{|p^{k-1}\rangle^2-1)\bar{g}_{L_c}\Big] \qquad (3)$$

where $\langle p^k\{|p^{k-1}\rangle$ is the coefficient of fractional parentage.

Starting from Eq.(3) we can derrive /3/ the following expression:

$$\omega \approx \frac{AN_e}{T^{1/2}}\Big[\frac{\alpha}{(I_0-E_i)^2} + \sum_{L_c}\frac{\beta}{(I_0+E_{L_c})^2} + \frac{\gamma}{I_0-E_i} - \sum_{L_c}\frac{\eta}{I_0+E_{L_c}}\Big] \qquad (4)$$

where I_0 is the ionization energy, E_i the energy of (n+1)s level and E_{L_c} the parent term energy counted from the ground level of the next ionization stage. In calculating $|\langle i|(\vec{r}/a_0)|f\rangle|^2$, we have introduced an averaged Bates and Damgaard factor for resonance lines with the same k and different n.

Table 1. Empirically obtained a and b coefficients for different number k of equivalent electrons.

k	a	b	k	a	b
1	-4.7696	0.7938	4	-4.9112	0.7891
2	-4.2500	0.7652	5	-5.0737	0.8011
3	-4.7924	0.7909	6	-5.3842	0.8104

We have found that between the energy of $np^{k-1}(n+1)s$ level - E_i and I_0 there exists a relationship, which may be approximately expressed as $E_i = a + bI_0$. Corresponding coefficients a and b are given in Table 1.

The Eq.(4) may be expressed now as a series in terms of I_0:

$$\omega = \sum_{n=1}^{\infty} A_n(T,N_e,k)\ I_0^{-n} \qquad (5)$$

Coefficients A_n are calculated and given in /3/.

If we want to obtain the half-halfwidth in wavelength units, the conversion factor is

$$\lambda^2/2\pi c \approx (h^2c/2\pi b^2 I_0^2)(1-(2a/bI_0)). \qquad (6)$$

and

$$w = \sum_n B_n(N_e,T,k)\ I_0^{-n},\ n \geq 3. \qquad (7)$$

If we retain only the most important term in Eq.(7), we obtain the relation similar to that derived in /1/(Eqs.2):

$$w,d \approx \pm \frac{AN_e}{T^{1/2}}\frac{5E_H^2 z^2 \hbar^2 c}{4\pi b^2}\Big[(1-b)^{-2} \pm K \pm \frac{2Kq}{z^2E_H^2 b(1-b)}\Big] I_0^{-4} \qquad (8)$$

where the minus sign is for the shift, in which case the expression is obtained in a similar way /3/.

For T = 20000K, $N_e = 10^{17}$ cm^{-3} and k =1, our result is w(Å) ≈ 1655 I_0^{-4}, |d| (Å) = 1665 I_0^{-4}, and for k =6, w(Å) ≈ 1730 I_0^{-4}, |d| (Å) ≈ 2001 I_0^{-4}. The results obtained, are relatively close to the results obtained in /1/ for the case without equivalent electrons. We can see that the difference between the case with six and without equivalent electrons is 20% for the shift and 4.5% for the width.

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IN MEMORIAM OF ACADEMICIAN J. XANTHAKIS

ΠΡΟΓΡΑΜΜΑ & ΠΕΡΙΛΗΨΕΙΣ ΕΡΓΑΣΙΩΝ

PROGRAMME & ABSTRACTS

ΘΕΣΣΑΛΟΝΙΚΗ 29 ΙΟΥΝΙΟΥ - 1 ΙΟΥΛΙΟΥ 1995

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THE $He - He^*(N)$ IONIZATION AND $He - He^+ - He$ RECOMBINATION IN STELLAR ATMOSPHERES

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Abstract

On the basis of the semi-classical theory, the rate coefficients of collisional $He - He^a st(n)$ ionization and recombination during electron scattering on $He - He^+$ complexes and He_2^+ ions were determined in this paper. The calculations were carried out in the case of non-equilibrium helium plasma with atomic temperature T_a and electronic temperature T_e, within the ranges 500 K $\leq T_a \leq$ 10000 K and 2000 K $\leq T_e \leq$ 40000 K, with the principal quantum number $3 \leq n \leq 10$. Such conditions correspond to the atmospheres of some types of helium-rich stars (see e.g. Koester, 1980). We have determined here as well, the conditions under which the considered processes are important for the kinetics of weakly ionized helium-rich star plasma. It has been shown as well that these processes can have a significant influence on the excited states of helium atom populations, in the lower part of Rydberg's domain, at $n \leq 10$. The results have been given in such a form that they can be used directly when modelling weakly ionized helium-rich star plasma.

ON THE STARK BROADENING OF CV LINES IN STELLAR ATMOSPHERES

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Abstract

Line profiles study of carbon ions in different ionization stages is of particular astrophysical interest, since such lines are present in stellar atmospheres. For studies as *e.g.* numerical modelling of stellar plasma or abundance determinations, data on C V lines are of importance. Stark broadening parameters are needed especially for hot and dense stars. A good example are PG 1159 pre-white dwarfs with effective temperature 100,000 - 140,000 K where carbon and helium are the dominant constituents (C/He = 0.5, Werner *et al.* 1991). Other astrophysical applications have been pointed out in more detail in Dimitrijevi'c and Sahal - Bréchot, 1992). By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 25 C V multiplets, in order to continue our research of multiply charged ion line Stark broadening parameters. We present and discuss here the obtained results and their astrophysical meaning.

ELECTRON-IMPACT BROADENING OF MG II LINES FOR SOLAR AND STELLAR ATMOSPHERES INVESTIGATIONS

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Abstract

The ionized magnezium lines are of particular astrophysical interest not only because of their presence in solar and stellar spectra and Mg abundance but also for the modelling of solar and stellar atmospheres, since Mg influence on the atmospheric electron density is important. Data of importance for such investigations are also electron - impact (Stark) broadening parameters, particularly important for transitions involving highly excited states, and for the considerations of subphotospheric layers. By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 67 Mg II multiplets, within the temperature range 5000 - 15000 K and for electron densities 10^{15} - 10^{19} cm^{-3}. For perturber densities smaller than 10^{15} cm^{-3}, the linear scaling of data may be used. We present and discuss here the obtained results and their astrophysical meaning. The comparison with experimental data and other calculations is made as well.

AN INTERPRETATION OF THE LIGHT CURVE OF THE CLOSE BINARY ACTIVE CATACLISMIC VARIABLE Z CHA BY USING THE INVERSE-PROBLEM METHOD

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Abstract

In the pQaper considered is a model synthetising the light curves of novae and novae-like stars, as well as of active close binaries (CB) in the phase of an intensive matter exchange between the components. The model can successfully describe the essential characteristics of the observed asymmetric light curves deformed due to existence of an accretion disc and a hot spot, taking into account the radial and azimuthal temperature distributions in the disc. The analysis of the observed light curves is performed by using the inverse-problem method (Djurasevic, 1992) adapted to this model. The interpretation of photometric observations is based on the choice of optimal model parameters yielding the best agreement between an observed light curve and the corresponding synthetic one. Some of the parameters can be determined a priori in an independent way, while the others are found by solving the inverse problem. In the particular case the parameters for the dwarf-nova Z Cha are estimated on the basis of the observations (Warner, 1974).

UNIMODALITY OF GLOBULAR CLUSTER METALLICITY FUNCTION.

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Abstract

Existence of secondary peaks in the globular cluster metallicity function noted by some authors at last two decades and interpreted as indication of some active phases in the evolution of Galaxy. This conclusion is so important that it is worthwhile to recall to the initial data and check the reality (statistical significance) of these peaks. This is just the aim of present study. The probability and statistical considerations show that, in spite of previous statements, these peaks have no statistical significance. They are the results of random fluctuations connected with the arbitrary choise of interval size and even its zero-point. It is shown that the distribution of metallicity at high-metallicity tail of metallicity function can be considered as uniform. Then the question arises about the reality of the models which are based on the assumption about the reality of these peaks.

MULTIDIMENSIONAL STATISTICAL ANALYSIS OF STAR CLUSTERS

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Abstract

We present the results of our study of star clusters, both open and globular, by multidimensional statistical analysis. All three branches of this analysis are included, i.e. cluster, or taxonomical analysis; factor analysis (principal component method); and, finally, pattern recognition. The main results are following. 1. It is shown by taxonomical analysis that more than half of open clusters, OB-associations,

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The He - He$^+$ - He recombination and He - He*(n) ionization in stellar atmospheres

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Abstract

On the basis of the semi-classical theory, the rate coefficients of collisional $He - He^*(n)$ ionization and recombination during electron scattering on $He-He^+$ complexes and He_2^+ ions were determined. The calculations were carried out in the case of non-equilibrium helium plasma with atomic temperature T_a and electronic temperature T_e, within the ranges 500K $\leq T_a \leq$ 10000K and 2000K $\leq T_e \leq$ 40000K, with the principal quantum number $4 \leq n \leq 10$. Such conditions correspond to the atmospheres of some types of helium-rich stars. We have determined here, as well, the conditions under which the considered processes are important for the kinetics of weakly ionized helium-rich star plasma. It has been shown as well that these processes can have a significant influence on the excited states of helium atom populations, in the lower part of Rydberg's domain, at $n \leq 10$.

1 Introduction

It was demonstrated [1,2] that in weakly ionized plasmas, $A_2^+ + e$ dissociative recombination process and recombination process $A + A^+ + e$ may have the same importance as a source of highly excited (Rydberg) atoms $A^*(n)$, where n denotes the principal quantum number.

The principal aim here is to demonstrate that such recombination processes, neglected up to now, may have important or even dominant role as a source of highly excited atoms, in comparison with already known recombination processes, for conditions corresponding to the atmospheres of some types of helium-rich stars. In order to do so we will consider relatively weakly ionized helium plasma (the ionization degree less or equal to 10^{-3}), characterized in general case by electronic temperature, T_e, and atomic temperature, T_a, where $T_a \leq T_e$. For such a plasma we will determine the rate coefficients of dissociative and electron - ion - atom recombination processes

$$He_2^+ + e \Longrightarrow He^*(n) + He(1s^2) \qquad (1a)$$

$$He^+(1s) + He(1s^2) + e \Longrightarrow He^*(n) + He(1s^2), \qquad (1b)$$

where He_2^+ denotes molecular helium ion in the ground electronic state, and $He^*(n)$ – helium atom in a highly excited state ($n \geq 4$). The rate coefficients for the (1a,b) processes will be compared with the rate coefficients of the electron - electron - ion recombination processes

$$He^{+}(1s) + e + e \Longrightarrow He^{*}(n) + e, \tag{2}$$

important for a large electron densities and temperature range and usually taken into account for stellar plasma modelling.

We will take into account as well that, in astrophysical plasmas, the (1a), (1b) and (2) processes occur always together with the inverse ionization processes

$$He^{*}(n) + He(1s^{2}) \Longrightarrow e + He_{2}^{+} \tag{3a}$$

$$He^{*}(n) + He(1s^{2}) \Longrightarrow e + He^{+}(1s) + He(1s^{2}) \tag{3b}$$

$$He^{*}(n) + e \Longrightarrow He^{+}(1s) + e + e, \tag{4}$$

which decrease the $He^{*}(n)$ atom population. Since the chemi-ionization process (3a,b) were not as well taken into account for stellar plasma modelling, we will compare them here with the known electron - impact ionization processes (4). Consequently, we will determine the rate coefficients of processes (3a) and (3b).

The rate coefficients of the recombination processes (1a,b) and the ionization processes (3a,b) will be denoted here as $K_{r}^{a,b}(n,T_{a},T_{e})$ and $K_{i}^{a,b}(n,T_{a})$ respectively. They will be determined here within the framework of the existing semi-classical theory, based on the mechanism of resonant energy conversion within the electronic component of the observed atomic system. This theory describes ionization in the case of an atom – Rydberg atom symmetrical collisions [1,2] and recombination in the case of electron scattering on the corresponding ion – atomic complexes and molecular ions [3], under conditions similar to those in stellar weakly ionized plasmas.

The rate coefficients of the electron - electron - ion recombination processes (2) and of the electron-impact ionization processes (4) will be denoted here as $\alpha_{r}(n,T_{e})$ and $\alpha_{i}(n,T_{e})$ respectively.

2 Theory

The contribution of the (1a) and (1b) recombination processes to the He$^{*}(n)$ atom population may be characterized by the partial recombination fluxes $I_{r}^{a}(n)$ and $I_{r}^{b}(n)$ as well as the total recombination flux $I_{r}^{ab}(n) = I_{r}^{a}(n) + I_{r}^{b}(n)$. Under conditions described in Ref. 4, we will further express the recombination fluxes $I_{r}^{a,b}(n)$ and $I_{r}^{ab}(n)$ as

$$I_{r}^{a,b}(n,T_{a},T_{e}) = K_{r}^{a,b}(n,T_{a},T_{e})N(He)N(He^{+})N(e),$$

$$I_{r}^{ab}(n,T_{a},T_{e}) = K_{r}^{ab}(n,T_{a},T_{e})N(He)N(He^{+})N(e),$$

where

$$K_{r}^{ab}(n,T_{a},T_{e}) = K_{r}^{a}(n,T_{a},T_{e}) + K_{r}^{b}(n,T_{a},T_{e}).$$

Here,

$$K_{r}^{a} = K_{dr}[N(He_{2}^{+})/N(He)N(He^{+})],$$

where K_{dr} is the dissociative recombination rate coefficient [4] and $N(He)$, $N(He^+)$, $N(He_2^+)$ and $N(e)$ denote He, He^+, He_2^+ and free electron densities respectively.

The recombination process (2) contribution to the He*(n) atom population may be characterized by the recombination flux $I_r^{el}(n,T_e) = \alpha_r^{el}(n,T_e)N^2(e)N(He^+)$. Consequently, the relative influence of the (1a,b) and (2) recombination processes on the He*(n) atom populations may be characterized by the ratio $I_r^{ab}(n,T_a,T_e)/I_r^{el}(n,T_e)$, where

$$I_r^{ab}/I_r^{el} = [K_r^{ab}(n,T_a,T_e)/\alpha_r^{el}(n,T_e)][N(He)/N(e)]. \tag{5}$$

The determination of the rate coefficients $K_r^{a,b}$ and K_r^{ab} is described in detail in Ref. 4.

The influence of the chemi-ionization processes (3a,b) on the He*(n) atom population may be characterized by the partial ionization fluxes $I_i^{a,b}(n)$ and the total ionization flux $I_i^{ab}(n) = I_i^a(n) + I_i^b(n)$

Under conditions described in Ref. 4, these fluxes may be expressed as

$$I_i^{a,b}(n,T_a) = K_i^{a,b}(n,T_a)N(He^*(n))N(He)$$

and

$$I_i^{ab}(n,T_a) = K_i^{ab}(n,T_a)N(He^*(n))N(He),$$

where

$$K_i^{ab}(n,T_a) = K_i^a(n,T_a) + K_i^b(n,T_a),$$

and $N(He^*(n))$ is the $He^*(n)$ atom density.

The electron-impact process (4) contribution to the He*(n) atom population may be characterized by the ionization flux

$$I_i^{el}(n,T_e) = \alpha_i^{el}(n,T_e)N(e)N(He^*(n)).$$

Consequently, the relative influence of the (3a,b) and (4) ionization processes on the He*(n) atom populations may be characterized by the ratio $I_i^{ab}(n,T_a)/I_i^{el}(n,T_e)$, where

$$I_i^{ab}/I_i^{el} = [K_i^{ab}(n,T_a)/\alpha_i^{el}(n,T_e)][N(He)/N(e)]. \tag{6}$$

The determination of the chemi - ionization rate coefficients $K_i^{a,b}$ and K_i^{ab} is described in detail in Ref. 4.

3 Results and discussion

We calculated the rate coefficients $K_r^{a,b}$ and K_r^{ab} for principal quantum number n values from 4 up to 10 and for the temperature ranges 2000K $\leq T_a \leq$ 10000K and 2000K $\leq T_e \leq$ 40000K. The performed calculations are illustrated in Table 1, where K_r^{ab} values for $T_e = T_a$ are shown. This Table gives an idea of the order of magnitude of these rate coefficients. It has a practical meaning as well, since these values may be applied for non equilibrium plasma modelling, for $T_e = T_a$, but without the Boltzmann distribution for the $He^*(n)$ atom population [5]. The relative importance of the (1a) and (1b) channels was considered here as well. For this reason, the ratio $I_r^b/I_r^{ab} = K_r^b/K_r^{ab}$ is determined within the same n, T_e and T_a ranges. It was found that this ratio behavior, as a function of T_a and T_e for given n, is, mostly, not significantly different from the hydrogenic case considered in Ref. 3. In order to determine the importance of the (1a,b) recombination processes, as the $He^*(n)$ atom source, in comparison with the electron – electron – ion recombination processes (2), the behaviour of the $I_r^{ab}(n, T_a, T_e)/I_r^{el}(n, T_e)$ ratio, defined by Eq. (5), was investigated within the same ranges of n, T_a and T_e. We found that the (1a,b) processes are more important than the electron - electron - ion recombination processes (2) within the considerable part of the investigated ranges. It has been found as well that with the increase of n, the relative influence of the (a,b) processes decreases rather quickly. Consequently, these processes are important for the lower part of the Rydberg states domain ($n \leq 10$). Moreover, it has been found that the $I_r^{ab}(n, T_a, T_e)/I_r^{el}(n, T_e)$ ratio for fixed n, T_e and $N(He)/N(e)$, decreases monotonically when T_a increases.

Table 1. Calculated values of coefficients K_r^{ab} as a function of n and T_a for $T_e = T_a$.

T_a	$n = 4$	$n = 6$	$n = 8$	$n = 10$
2000	0.3682(-27)	0.9020(-28)	0.4590(-28)	0.2969(-28)
4000	0.5456(-28)	0.2406(-28)	0.1488(-28)	0.1043(-28)
6000	0.2369(-28)	0.1244(-28)	0.8116(-29)	0.5806(-29)
8000	0.1408(-28)	0.7994(-29)	0.5337(-29)	0.3848(-29)
10000	0.9664(-29)	0.5727(-29)	0.3868(-29)	0.2798(-29)

For the chemi – ionization processes (3a,b), the total ionization rate coefficient K_i^{ab} values for given n and T_a may be determined on the basis of the thermodynamical balance principle. Namely, for n from 4 up to 10 and 2000K $\leq T_a \leq$ 10000K they may be calculated by the multiplication of the corresponding K_r value from the Table 1 with the factor $[N(He^+)N(e)/N(He^*(n))]$, which value is determined for LTE with the given temperature T_a. We note that the factor in the square brackets is the Saha function, with the $He^*(n)$ state taken instead of the He ground state. The relative importance of the chemi – ionization processes (3a,b), compared to the electron – impact atom ionization processes (4), has been considered by the corresponding analysis, which will be given elsewhere [4]. It has been found (calculations were performed for $n = 4$, and 2000K $\leq T_e \leq$ 40000K), that the ratio $I_i^{ab}(n, T_a)/I_i^{el}(n, T_e)$, defined by Eq. (6), increases monotonically when T_a increases, for fixed n, T_e and $N(He)/N(e)$. In spite of the fact that the relative importance of the chemi - ionization processes (3a,b), in comparison with the electron - atom ionization processes (4), is significantly smaller than the relative importance of the recombination processes (1a,b) in comparison to the processes (2), our analysis shows that the chemi - ionization processes (3a,b) should be considered as well for the modelling of relatively low temperature astrophysical helium plasma of some types of helium-rich stars [4], with plasma conditions described in Refs. 6 and 7.

4 Conclusion

The principal result of the article is the demonstration of the fact that, previously neglected recombination processes (1a,b) in low temperature plasma, characteristic for some types of helium-rich stars, are an important and in particular cases even a dominant factor, influencing the population of highly excited $He^{*}(n)$ atomic states. This fact is stated by the comparison of these processes with the well known electron–electron–ion recombination processes. A similar, but less significant fact, is found for the chemi-ionization processes (3a) and (3b). The results are obtained for nonequilibrium He plasmas and for ionization degrees less than or of the order 10^{-3}. These results may be of interest for helium-rich star atmospheres investigations and modelling as well as for the laboratory plasmas.

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On the Stark broadening of C v lines in stellar atmospheres

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Abstract

By using the semiclassical-perturbation formalism, we have calculated electron-, proton-, and He III- impact line widths and shifts for 25 C v multiplets, in order to continue our research of multiply-charged ion line Stark broadening parameters. We present and discuss here the obtained results and their astrophysical importance.

1 Introduction

Line broadening data for spectral lines of carbon ions in different ionization stages are of particular astrophysical interest, since such lines are present in stellar atmospheres. For studies as *e.g.* numerical modelling of stellar plasma or abundance determinations, data on C v lines are of importance. Stark broadening parameters are needed especially for hot and dense stars. A good example are PG 1159 pre-white dwarfs with an effective temperature of 100,000 - 140,000 K, where carbon and helium are the dominant constituents (C/He = 0.5 [1]). Other astrophysical applications have been pointed out in more detail in Ref. 2. Stark broadening of C v lines is as well of interest for the diagnostic of laser-produced plasma and for the research of regularities and systematic trends.

Stark widths of two quasihydrogen-like C v lines (5-6 and 6-7 transitions) from plasma produced by laser irradiation of polyethylene foil in vacuum, have been measured in Ref. 3. Line profiles of C v were measured in a carbon laser produced plasma [4,5]. Stark widths of C v $3s^1S$ - $3p^1P^o$, $1s^2\ {}^1S$ - $3p^1P^o$ and $2s^1S$ - $3p^1P^o$, were determined within the modified semiempirical approach [6] in Ref. 7. Stark widths for C v $3s^1S$ - $3p^1P^o$ multiplet, obtained within the simplified semiclassical approach [8], are given in Ref. 9. Moreover, Stark broadening parameters for C v $2s^3S$ - $2p^3P^o$ multiplet were determined theoretically in Ref. 10.

Table 1: This table shows electron-, proton-, and He III- impact broadening parameters for C V for perturber density of 10^{17}cm^{-3} and temperatures from 5,000 up to 150,000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By dividing c with the corresponding linewidth [12], we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

PERTURBER DENSITY = 1xE+17cm-3							
PERTURBERS ARE:		ELECTRONS		PROTONS		He III	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
C V 1S 2P	50000.	0.297E-05	-0.126E-06	0.121E-07	-0.203E-07	0.218E-07	-0.396E-07
40.3 A	100000.	0.211E-05	-0.483E-07	0.333E-07	-0.402E-07	0.614E-07	-0.801E-07
C= 0.47E+17	150000.	0.174E-05	-0.196E-07	0.558E-07	-0.574E-07	0.105E-06	-0.116E-06
	200000.	0.152E-05	-0.163E-07	0.748E-07	-0.710E-07	0.142E-06	-0.144E-06
	300000.	0.127E-05	-0.117E-07	0.108E-06	-0.929E-07	0.209E-06	-0.189E-06
	500000.	0.102E-05	-0.115E-07	0.151E-06	-0.119E-06	0.290E-06	-0.243E-06
C V 2S 2P	50000.	0.343E-01	-0.114E-02	0.153E-03	-0.686E-03	0.280E-03	-0.134E-02
3478.6 A	100000.	0.249E-01	-0.108E-02	0.550E-03	-0.125E-02	0.105E-02	-0.250E-02
C= 0.35E+21	150000.	0.208E-01	-0.120E-02	0.967E-03	-0.165E-02	0.186E-02	-0.336E-02
	200000.	0.185E-01	-0.121E-02	0.133E-02	-0.190E-02	0.264E-02	-0.389E-02
	300000.	0.156E-01	-0.114E-02	0.181E-02	-0.231E-02	0.361E-02	-0.473E-02
	500000.	0.129E-01	-0.111E-02	0.269E-02	-0.276E-02	0.533E-02	-0.570E-02
C V 2P 3S	50000.	0.609E-03	0.516E-04	0.258E-04	0.539E-04	0.499E-04	0.106E-03
272.2 A	100000.	0.463E-03	0.567E-04	0.521E-04	0.760E-04	0.105E-03	0.154E-03
C= 0.61E+18	150000.	0.400E-03	0.560E-04	0.750E-04	0.886E-04	0.151E-03	0.182E-03
	200000.	0.362E-03	0.547E-04	0.863E-04	0.950E-04	0.175E-03	0.195E-03
	300000.	0.316E-03	0.533E-04	0.104E-03	0.106E-03	0.209E-03	0.218E-03
	500000.	0.269E-03	0.503E-04	0.127E-03	0.121E-03	0.253E-03	0.250E-03
C V 2P 3D	50000.	0.459E-03	0.238E-04	0.318E-04	0.568E-04	0.610E-04	0.112E-03
267.6 A	100000.	0.345E-03	0.263E-04	0.621E-04	0.800E-04	0.118E-03	0.161E-03
C= 0.13E+18	150000.	0.294E-03	0.270E-04	0.903E-04	0.921E-04	0.167E-03	0.190E-03
	200000.	0.264E-03	0.249E-04	0.105E-03	0.994E-04	0.190E-03	0.204E-03
	300000.	0.227E-03	0.238E-04	0.130E-03	0.111E-03	0.228E-03	0.227E-03
	500000.	0.191E-03	0.223E-04	0.167E-03	0.127E-03	0.274E-03	0.260E-03
C V 2S 2P	50000.	0.131E-01	-0.255E-03	0.412E-04	-0.173E-03	0.750E-04	-0.337E-03
2274.6 A	100000.	0.939E-02	-0.317E-03	0.142E-03	-0.328E-03	0.265E-03	-0.655E-03
C= 0.23E+21	150000.	0.780E-02	-0.364E-03	0.248E-03	-0.441E-03	0.480E-03	-0.892E-03
	200000.	0.688E-02	-0.386E-03	0.364E-03	-0.533E-03	0.709E-03	-0.109E-02
	300000.	0.580E-02	-0.386E-03	0.501E-03	-0.643E-03	0.995E-03	-0.131E-02
	500000.	0.473E-02	-0.374E-03	0.763E-03	-0.809E-03	0.150E-02	-0.166E-02
C V 2S 3P	50000.	0.506E-03	0.680E-05	0.118E-04	0.148E-04	0.224E-04	0.291E-04
227.2 A	100000.	0.380E-03	0.617E-05	0.226E-04	0.228E-04	0.443E-04	0.463E-04
C= 0.30E+18	150000.	0.325E-03	0.665E-05	0.299E-04	0.277E-04	0.582E-04	0.568E-04
	200000.	0.293E-03	0.575E-05	0.364E-04	0.313E-04	0.706E-04	0.643E-04
	300000.	0.254E-03	0.594E-05	0.431E-04	0.348E-04	0.821E-04	0.714E-04
	500000.	0.214E-03	0.515E-05	0.531E-04	0.398E-04	0.975E-04	0.823E-04

2 Results and discussion

All details of the calculations will be given elsewhere ([11] and Sahal-Bréchot, 1969). Our results for 25 C v multiplets, for perturber densities 10^{17} - 10^{22}cm^{-3} and temperatures T = 50,000 - 1,000,000K will be published in Ref. 11. Here only a sample of results will be presented in Table 1. We also specify a parameter c [12], which gives an estimate for the maximum perturber density for which the line may be treated as isolated, when it is divided by the corresponding electron-impact full width at half maximum. For each value given in Table 1, the collision volume (V) multiplied by the perturber density (N) is much less than one and the impact approximation is valid [13,14]. The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

In addition to the data presented here, Stark widths of C v $3s^1S$ - $3p^1P^o$, $1s^2\ ^1S$ - $3p^1P^o$ and $2s^1S$ - $3p^1P^o$, (where a sufficiently complete set of reliable energy levels needed for the adequate application of the semiclassical perturbation method does not exist), determined within the modified semiempirical approach [6] are given in Ref. 7. Moreover, Stark widths for C v $3s^1S$ - $3p^1P^o$ multiplet, obtained within the symplified semiclassical approach [8], are given in [9]. Stark width for C v $2s^3S$ - $2p^3P^o$ multiplet was determined theoretically in Ref. 10, but the authors obtain considerably smaller value.

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IN MEMORIAM OF ACADEMICIAN J. XANTHAKIS

ΠΡΟΓΡΑΜΜΑ & ΠΕΡΙΛΗΨΕΙΣ ΕΡΓΑΣΙΩΝ

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NEUTRON STARS MODELS WITH SPLINE-FITTED EQUATION OF STATE

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Abstract

In order to integrate the differential equation system which describes the structure of a neutron star (Oppenheimer and Volkoff, 1939)

$$\frac{dM(r)}{dr} = 4r^2(r)$$

$$\frac{dP}{dr} = [illegible]$$

$P = P()$

the equation of state $P = P()$ given by means of discrete values was fitted by Yoshimoto- type cubic splines (Yoshimoto 1977). For each interval $^{(i)} \geq x \geq x^{(i+1)}$, i=1,2...6, the third degree polynomial is given by $S_i(x) = m_i a_i(x) + m_{i+1} b_i(x) + y_i c_i(x) + y_{i+1} d_i(x)$ where $a_i(x) = \frac{[x^{(i+1)}-x]^2[x-x^{(i)}]}{h_i^2}$ $b_i(x) = -\frac{[x-x^{(i)}]^2[x^{(i+1)}-x]}{h_i^2}$ $c_i(x) = \frac{[x^{(i+1)}-x]^2[2(x-x^{(i)})+h_i]}{h_i^3}$ $d_i(x) = \frac{[x-x^{(i)}]^2[2(x^{(i+1)}-x)+h_i]}{h_i^3}$ and $h_i = x^{(i+1)} - x^{(i)}$
The integration yields $M = 1.36M_{\odot}$, R = 6.8 km and gravitational packing coefficient k=0.48, these resulta being in agreement with the corresponding values determined observationally for radiopulsars belonging to binary systems (Taylor and Westberg, 1989; Thorsett et. al. 1993).

THE INNES CONSTANTS FOR A DOUBLE STAR AS FUNCTIONS OF THE AXES AND OF THE APPARENT-ORBIT-POSITION PARAMETERS

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Abstract

Bearing in mind the geometrical meaning of the Innes constants A, B, F and G the analytical expressions for these constants as functions of the axes and of the apparent-ellipse-positions parameters of a double star are given. This procedure has been successfully applied to several double stars. A set of orbital elements is also presented here. The elements obtained in this way can be used as the initial ones in the application of Eichhorn's procedure.

STARK BROADENING OF GE II AND GE IV LINES

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Abstract

Stark with data for large number of transitions in many atomic and ionic spectra are needed for astrophysical and physical modeling of stellar and laboratory plasma. Stark broadening mechanism is important in hot stars with $T_{eff} \gtrsim 10000$ K, where it is main pressure broadening mechanism. However, Stark broadening of lines originating from energy levels with large principle quantum numbers may be important even for cooler stars. Spectral lines of ionized germanium (Ge II, Ge III) are presented in spectra of hot stars, as e.g. in spectra β Ori (Selvelli et al. 1977). Here we present Stark width for several Ge III and Ge IV spectral lines. For calculation the modified semi-empirical approach given by Dimitrijevi'c Konjevi'c (1980) has been used. The atomic data needed for calculation are taken from Moore's tables (1971) and oscillator strength from Migdalek (1977).

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Electron-impact broadening of Mg II lines for solar and stellar atmospheres investigations

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Abstract

By using the semiclassical-perturbation formalism, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 52 Mg II multiplets, as a function of temperature and perturber density.

1 Introduction

Due to the cosmical abundance of magnesium and its ionization potential value, Mg II lines are present in solar and stellar spectra and the corresponding Stark broadening data are of interest for their analysis. In order to provide to astrophysicists the needed Stark broadening data, we have calculated within the semiclassical-perturbation formalism [1,2] electron-, proton-, and ionized helium-impact line widths and shifts for 52 Mg II multiplets.

2 Results and discussion

All details of calculations as well as the comparison with available experimental and theoretical data will be published elsewhere [3]. Our results for 52 Mg II multiplets, for perturber densities of 10^{16}– 10^{19} cm^{-3} and temperatures T = 5,000 – 150,000 K will be published in Ref. 3. Here, in Table 1, we present only a part of obtained results for Stark broadening parameters as a sample. We also specify a parameter c [4], which gives an estimate for the maximum perturber density for which the line may be treated as isolated when it is divided by the corresponding full width at half maximum. For each value given in Table 1, the collision volume (V) multiplied by the perturber density (N) is much less than one and the impact approximation is valid [1,2]. The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

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Table 1: This table shows electron-, proton-, and He II- impact broadening parameters for Mg II, for perturber density of $10^{16}\mathrm{cm}^{-3}$ and temperatures from 5,000 up to 150,000 K. Transitions and averaged wavelengths for the multiplet (in Å) are also given. By dividing c with the corresponding linewidth [4], we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

PERTURBER DENSITY = 1xE+16cm-3							
		ELECTRONS		PROTONS		IONISED HELIUM	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
Mg II 3s-3p	5000.	0.173E-01	-0.312E-04	0.263E-03	-0.641E-05	0.388E-03	-0.641E-05
2798.7 A	10000.	0.126E-01	-0.382E-04	0.475E-03	-0.133E-04	0.592E-03	-0.132E-04
C= 0.27E+20	20000.	0.911E-02	-0.443E-04	0.679E-03	-0.256E-04	0.773E-03	-0.244E-04
	50000.	0.651E-02	-0.493E-04	0.846E-03	-0.487E-04	0.906E-03	-0.421E-04
	100000.	0.559E-02	-0.541E-04	0.944E-03	-0.670E-04	0.990E-03	-0.564E-04
	150000.	0.525E-02	-0.513E-04	0.988E-03	-0.751E-04	0.101E-02	-0.628E-04
Mg II 3s-4p	5000.	0.726E-02	0.627E-03	0.565E-03	0.317E-04	0.691E-03	0.304E-04
1240.1 A	10000.	0.561E-02	0.391E-03	0.751E-03	0.563E-04	0.812E-03	0.509E-04
C= 0.14E+19	20000.	0.460E-02	0.286E-03	0.851E-03	0.818E-04	0.910E-03	0.713E-04
	50000.	0.416E-02	0.249E-03	0.968E-03	0.112E-03	0.993E-03	0.927E-04
	100000.	0.410E-02	0.204E-03	0.101E-02	0.134E-03	0.103E-02	0.110E-03
	150000.	0.405E-02	0.179E-03	0.103E-02	0.148E-03	0.103E-02	0.120E-03
Mg II 3s-5p	5000.	0.103E-01	0.868E-03	0.156E-02	-0.941E-04	*0.167E-02	-0.851E-04
1026.0 A	10000.	0.861E-02	0.661E-03	0.178E-02	-0.143E-03	0.190E-02	-0.125E-03
C= 0.44E+18	20000.	0.795E-02	0.446E-03	0.198E-02	-0.188E-03	0.204E-02	-0.157E-03
	50000.	0.822E-02	0.336E-03	0.210E-02	-0.240E-03	0.214E-02	-0.198E-03
	100000.	0.860E-02	0.226E-03	0.216E-02	-0.282E-03	0.218E-02	-0.228E-03
	150000.	0.867E-02	0.220E-03	0.219E-02	-0.305E-03	0.220E-02	-0.248E-03
Mg II 3s-6p	5000.	0.165E-01	-0.839E-03	*0.345E-02	-0.564E-03		
946.7 A	10000.	0.151E-01	-0.642E-03	*0.392E-02	-0.747E-03	*0.406E-02	-0.613E-03
C= 0.20E+18	20000.	0.153E-01	-0.456E-03	0.417E-02	-0.916E-03	*0.424E-02	-0.753E-03
	50000.	0.171E-01	-0.206E-03	0.436E-02	-0.113E-02	*0.439E-02	-0.916E-03
	100000.	0.184E-01	-0.137E-03	0.441E-02	-0.131E-02	0.443E-02	-0.103E-02
	150000.	0.186E-01	-0.832E-04	0.442E-02	-0.138E-02	0.444E-02	-0.113E-02
Mg II 3s-7p	5000.	0.282E-01	-0.554E-02				
907.4 A	10000.	0.271E-01	-0.426E-02	*0.764E-02	-0.204E-02		
C= 0.11E+18	20000.	0.289E-01	-0.273E-02	*0.803E-02	-0.251E-02		
	50000.	0.338E-01	-0.215E-02	*0.847E-02	-0.298E-02	*0.834E-02	-0.246E-02
	100000.	0.365E-01	-0.127E-02	0.888E-02	-0.345E-02	*0.836E-02	-0.289E-02
	150000.	0.369E-01	-0.106E-02	0.879E-02	-0.365E-02	*0.807E-02	-0.295E-02
Mg II 4s-4p	5000.	0.514	-0.124	0.318E-01	-0.904E-02	0.386E-01	-0.804E-02
9229.4 A	10000.	0.393	-0.917E-01	0.426E-01	-0.135E-01	0.456E-01	-0.117E-01
C= 0.78E+20	20000.	0.327	-0.670E-01	0.487E-01	-0.174E-01	0.514E-01	-0.145E-01
	50000.	0.313	-0.501E-01	0.564E-01	-0.222E-01	0.563E-01	-0.183E-01
	100000.	0.318	-0.397E-01	0.592E-01	-0.261E-01	0.596E-01	-0.210E-01
	150000.	0.318	-0.353E-01	0.626E-01	-0.278E-01	0.611E-01	-0.227E-01
Mg II 4s-5p	5000.	0.136	-0.101E-01	0.194E-01	-0.242E-02	*0.208E-01	-0.207E-02
3615.4 A	10000.	0.114	-0.806E-02	0.222E-01	-0.352E-02	0.236E-01	-0.295E-02
C= 0.54E+19	20000.	0.107	-0.696E-02	0.247E-01	-0.435E-02	0.254E-01	-0.359E-02
	50000.	0.113	-0.566E-02	0.262E-01	-0.554E-02	0.267E-01	-0.452E-02
	100000.	0.120	-0.521E-02	0.272E-01	-0.635E-02	0.270E-01	-0.509E-02
	150000.	0.121	-0.418E-02	0.269E-01	-0.678E-02	0.271E-01	-0.560E-02
Mg II 4s-6p	5000.	0.150	-0.996E-02	*0.301E-01	-0.534E-02		
2791.6 A	10000.	0.136	-0.125E-01	*0.342E-01	-0.700E-02	*0.353E-01	-0.576E-02
C= 0.17E+19	20000.	0.138	-0.830E-02	0.365E-01	-0.864E-02	*0.371E-01	-0.707E-02
	50000.	0.155	-0.816E-02	0.376E-01	-0.105E-01	*0.386E-01	-0.850E-02
	100000.	0.168	-0.606E-02	0.390E-01	-0.119E-01	0.381E-01	-0.968E-02
	150000.	0.170	-0.511E-02	0.397E-01	-0.128E-01	0.393E-01	-0.102E-01

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Société Tunisienne de Physique

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THEORIE CONVERGENTE SIMPLIFIEE : APPLICATION A L'ELARGISSEMENT STARK DE L'HELIUM NEUTRE

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Introduction

L'estimation de la largeur et le déplacement d'un grand nombre de raies spectrales sont nécessaires pour les calculs d'opacité et les calculs de modèles astrophysiques.

La méthode de Freudenstein and Cooper (1978) du calcul de la largeur des raies spectrales d'atomes neutres est étendue au cas multi-niveaux et au calcul des déplacements par Dimitrijevič and Konjevič(1986).

Le formalisme de départ utilisé dans ces calculs s'appuie sur la théorie de coupure développée parGriem et al. (1962) et Sahal-Brechot (1969). L'intégration sur le paramétre d'impact diverge aux faibles valeurs et la solution proposée consiste à séparer les collisions faibles qui sont traitées par la théorie des perturbations des collisions fortes où on utilise la section efficace de Lorentz-Weisskopf.

La théorie convergente, développée par Vainshtein et Sobel'Man (1959) dans l'approximation des deux niveaux, et appliquée par Bassalo, Cattani et Walder (1980 et 1982) pour calculer les largeurs et les déplacements des raies de l'hélium neutre, à l'avantage de traiter les collisions faibles et fortes au même temps et donc évite la détermination d'un paramètre d'impact minimum.

Dans ce travail, nous proposons une formule approximative d'élargissements Stark par simplification de la théorie convergente. Nous appliquons les résultats à une série de spectres [illegible]

Théorie

La demi-largeur w et le déplacement des raies spectrales d'atomes neutres dans un plasma sont donnés par (Griem 1974)

$$w + 1d = N_e \int_0^\infty v f(v) dv \int_0^\infty 2\pi\rho \{S_a(0)S_b^*(0) - 1\} d\rho \qquad (1)$$

où N_e est la densité électronique, f(v) represente la distribution de vitesse des électrons et ρ le paramètre d'impact correspondant.

Dans la théorie convergente w+id s'écrit comme :

$$w + id = N_e \int_0^\infty v f(v) dv \int_0^\infty 2\pi\rho \left[1 - e^{-i\{\alpha(\rho,v)\}_{av}} \right] d\rho \qquad (2)$$

ρ and v sont les parametres de la collision et f(v) la distribution de Maxwell des vitesses des électrons :

$$f(v) = \left(\frac{2}{\pi}\right)^{1/2} \left(\frac{m}{kT}\right)^{3/2} v^2 \exp\left(-\frac{mv^2}{2kT}\right) \qquad (3)$$

et

$$\{\alpha(\rho, v)\}_{av} = \frac{2}{3}\left(\frac{e^2}{\hbar\rho v}\right)^2 \sum_{a' \neq a} R_{jj'}^2 \left[B(z_{jj'}) - iA(z_{jj'})\right] \qquad (4)$$

$B(z)=z^2[K_0(|z|)I_0(|z|)-K_1(|z|)I_1(|z|)]$, $A(z)=z^2[K_0(|z|)^2-K_1(|z|)^2]$ et $z_{jj'}=\omega_{jj'}\rho/v$.

Quand on utilise une vitesse moyenne (Freudenstein and Cooper 1978), on obtient :

$$w + id = 2\pi N_e \bar{v} \int_0^\infty \rho \left[1 - e^{-i\{\alpha(\rho,\bar{v})\}_{av}} \right] d\rho \text{ et } m\bar{v}^2 = 3kT \qquad (5)$$

Nous avons exprimé ρ en fonction de z et défini une fonction $f_{jj'}(T)$ de façon que la largeur et le déplacement s'écrivent sous la forme :

$$w + id = N_e \bar{v}^3 \sum_{jj'} \frac{f_{jj'}(T)}{g_j \, \omega_{jj'}^2} \qquad (6)$$

où

$$f_{jj'}(T) = \int_0^{\infty} z\,[\,1 - \exp\{-\,i\,g_j\,\alpha_{jj'}(z\,,\bar{v})\}\,]\,dz \qquad (7)$$

et

$$\alpha_{jj'}(z\,,\bar{v}) = \frac{2}{3}\,\frac{e^4}{\hbar^2}\,\frac{R_{jj'}^2\;\omega_{jj'}^2}{\bar{v}^{\,4}}\left(\frac{B_s(z_{jj'})-iA_s(z_{jj'})}{z^2}\right) \qquad (8)$$

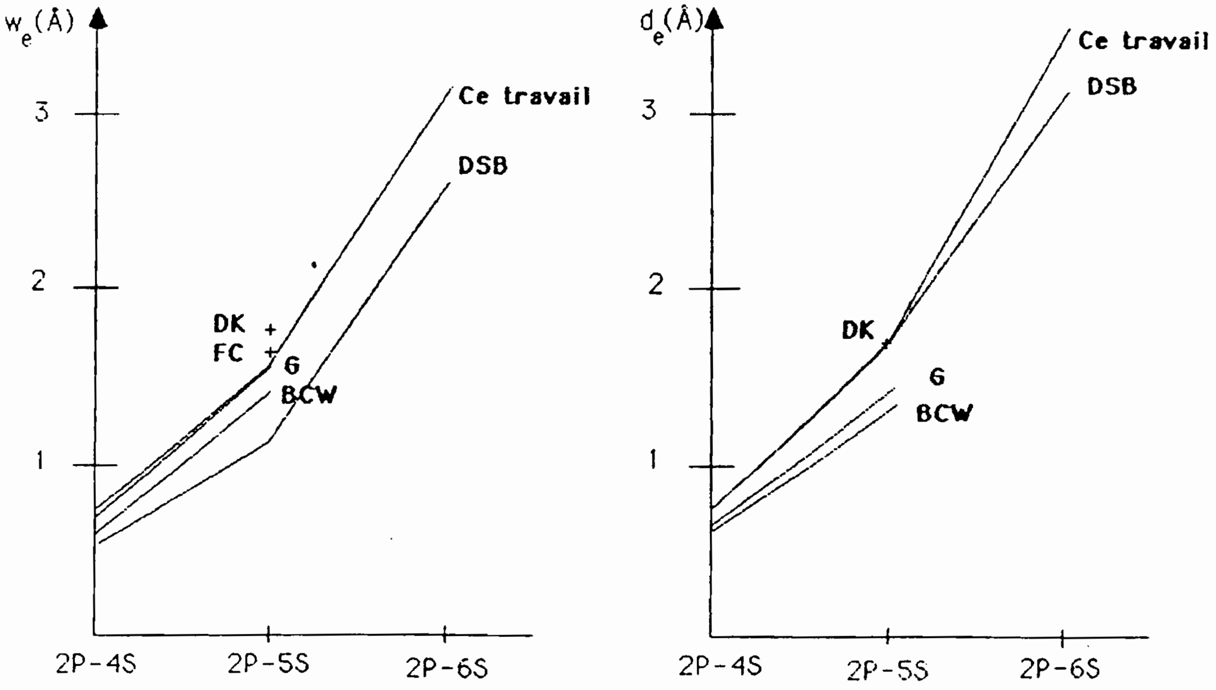
Les fonctions $A_s(z)$ and $B_s(z)$ sont les fonctions de collisions simplifiées. Ils répondent aux conditions aux limites des faibles et grandes valeurs de z et sont ajustées numériquement.

$$A_s(z) = e^{-2z}\,(\,a + b\,z\,)\ \text{et}\ B_s(z) = c\,z^2\,\mathrm{Log}\left(1 + \frac{d}{z^3}\right) \qquad (9)$$

avec a=0.90, b=3.12, c=1.4 et d= 0.7

Application à l'élargissement de l'hélium neutre

La figure suivante représente la largeur et le déplacement des raies de la série singulet de l'hélium neutre 2P-mS avec m=4, 5 et 6. Une comparaison est faite entre nos résultats de calcul et ceux obtenus avec la théorie de coupure de Griem (G, 1962) et la théorie convergente de Bassalo-Cattani-Walder (BCW, 1982) ainsi que les formules simplifiées de Freudenstein-Cooper (FK, 1978) et de Dimitrijevic-Konjevic (DK, 1986) et de Dimitrijevic-Sahal Bréchot (DSB, 1990)



Largeur et déplacement de la série 2S-mP de l'hélium neutre

$T=10^4\,K$ et $N_e = 10^{16}\,cm^{-3}$

Nos résultats de largeurs de raies sont en bon accord avec ceux obtenus à partir de la théorie de Griem . Pour le déplacement, nous trouvons des valeurs du même ordre de grandeur que celles obtenus avec les formules simplifiées (DK,1986).

CONCLUSION

La méthode de calcul présentée dans ce travail est très utile pour des calculs d'opacité quand l'élargissement Stark d'un grand nombre de raies est nécessaire.

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TREĆI SEMINAR

ASTROFIZIKA U JUGOSLAVIJI

Zagreb, 9/10. XI 1989.

PROGRAM I APSTRAKTI

UREDNIK: V. VUJNOVIĆ
INSTITUT ZA FIZIKU SVEUČILIŠTA
ZAGREB

SEMICLASSICAL CALCULATIONS OF ASTROPHYSICALLY IMPORTANT STARK BROADENING PARAMETERS

M.S.Dimitrijević[1] and S.Sahal-Bréchot[2]
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In many astrophysical problems as e.g. evaluation and modeling of the stellar atmospheric physical properties, opacity calculations or abundance determinations, Stark broadening data are often needed, especially in the case of O, A and B type stars and hot white dwarfs.

Using the semiclassical-perturbational formalism (1,2) we performed extensive calculations of electron-proton-and ionized helium-impact broadening parameters for 79 He I (3,4,5,8); 62 Na I (6,9) and 51 K I (7,9) multiplets. Now, we are preparing data for C IV and Si IV lines and calculations along Li isoelectronic sequence.

Obtained data have been used also for the investigation of regularities and similarities of Stark broadening parameters.

We will discuss obtained results as well as actual directions of our research.

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UREDNIK: V. VUJNOVIĆ
INSTITUT ZA FIZIKU SVEUČILIŠTA
ZAGREB

MODIFIED SEMIEMPIRICAL THEORY OF STARK BROADENING IN ASTROPHYSICS: ArII LINE SHIFTS IN SPECTRA OF B STARS

V.Kršljanin and M.S.Dimitrijević

Astronomical Observatory, Volgina 7, 11050 Beograd, Yugoslavia

For the numerous applications in physical and chemical analysis of stellar atmospheric properties, in constructing line blanketed model atmospheres and in solving radiative transport problems in both stellar atmospheres and interiors, astrophysicists need fast methods with good average accuracy for estimating pressure broadening parameters of many spectral lines. Modified semiempirical (MSE) theory of Stark broadening of ion lines [1,2] is such an approach. In the case of line widths it already showed its advantages in the impact with laboratory measurements and as a source of astrophysical data (see e.g.[3] and references therein). Recently, we examined [4-6] reliability of MSE formula for line shifts [2] by the comparison of MSE results with large sample of laboratory experimental data in the cases of ArII [4,5] and alcali-like singly charged ions lines [6]. Mean experimental to theoretical (MSE) Stark shift ratio for 18 experiments examined (with about 350 measured line shifts), including the recent one [7], is 1.2±0.4. The same ratio of semiclassical results [8] is found to be 0.8±0.3. Extensive tables of MSE Stark widths and shifts for 50 ArII multiplets are given in [5].

Stark shift produces important contribution to stellar spectral line asymmetries (e.g.[9,10]). In the Table 1, MSE Stark shifts of 4s^{4}P-4p^{4}D^o (7) and 4p^{4}D^o-5s^{4}P (52) ArII multiplets in atmospheres of B main sequence (log g=4.5) stars [11] are given. One can notice that the shifts in whole range of effective temperatures are practicaly unchanged. Measuring relative shifts of λλ 417.95447 nm and 418.04898 nm lines one can expect Stark shift contribution of 0.1 - 0.4 pm.

Table 1. ArII line shifts [m/s] in spectra of B stars

Multiplet	λ4362.6 (7)		λ4105.4 (52)	
$\tau_{500}\backslash T_{eff}$[K]	10000	30000	10000	30000
0.01	-1	-1	15	18
0.1	-5	-4	67	63
1	-20	-12	266	205

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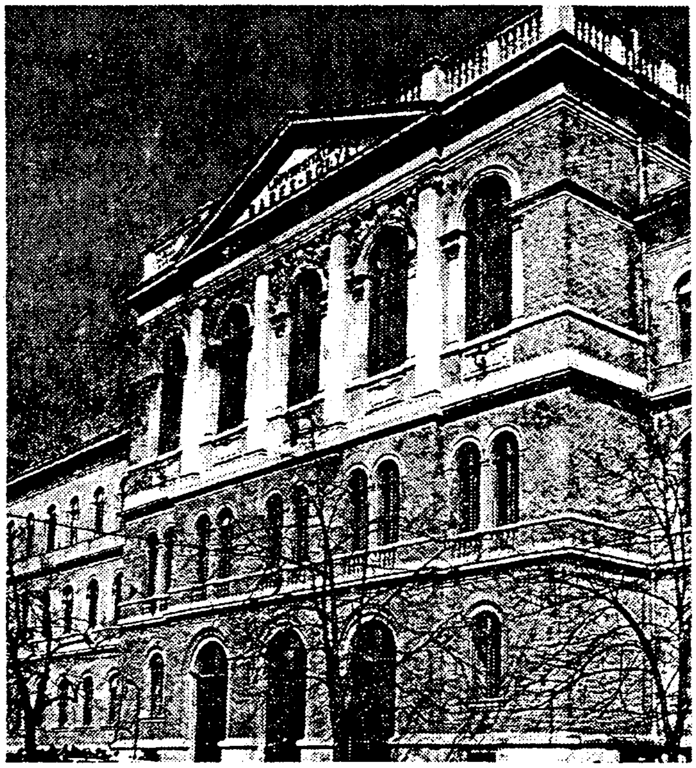
BPU-3

3rd GENERAL CONFERENCE OF THE BALKAN PHYSICAL UNION



2-5 September, 1997
CLUJ-NAPOCA, ROMANIA

PROGRAMME AND ABSTRACTS

50-005

ON THE STARK BROADENING OF O VII SPECTRAL LINES

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The study of the influence of impacts with charged particles (Stark broadening) on spectral line shapes of oxygen in various ionization stages is of importance for a number of problems in physics and astrophysics. For example, Stark broadening parameters for such ions are needed for the study of subphotospheric layers, for interpretation and modelling of some hot star spectra as PG1159 type stars, for stellar abundance determinations. opacity calculations, diagnostic of laser produced, fusion and laboratory plasmas etc.

By using the semiclassical-perturbation formalism, we have calculated electron-, proton-, and He III-impact line widths and shifts for a number of O VII multiplets, of importance for research, diagnostic and modelling of various astrophysical, laser produced, fusion and laboratory plasmas, in order to continue our effort to provide such data (see Ref. 1 and references therein).

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50-006

DECONVOLUTION OF LOW INTENSITY SPECTRAL LINES

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The paper presents a numerical deconvolution method of the low amplitude spectral lines. In many spectral investigations of plasma radiation the low intensity spectral lines are important indicators for some particular radiative processes like the excitations by second kind collisions. Their identifications permit the tuning of the discharge parameters to obtain selective excitations of plasma ions. Deconvolution techniques commonly used in plasma spectroscopy require the fast Fourier transform. These impose restrictive conditions on the form of the transfer function and on the value of the signal-to-noise ratio. Removals of the noise effects, performed by cutting off the high and the low frequencies with low amplitudes, induce the elimination of the weak spectral lines. The deconvolution technique developed in this paper is not affected by these inconvenients. It is based on an algorithm developed by Jansson [1], who use an iterative schema to recover the spectral lines shape by using operations in the signal space.

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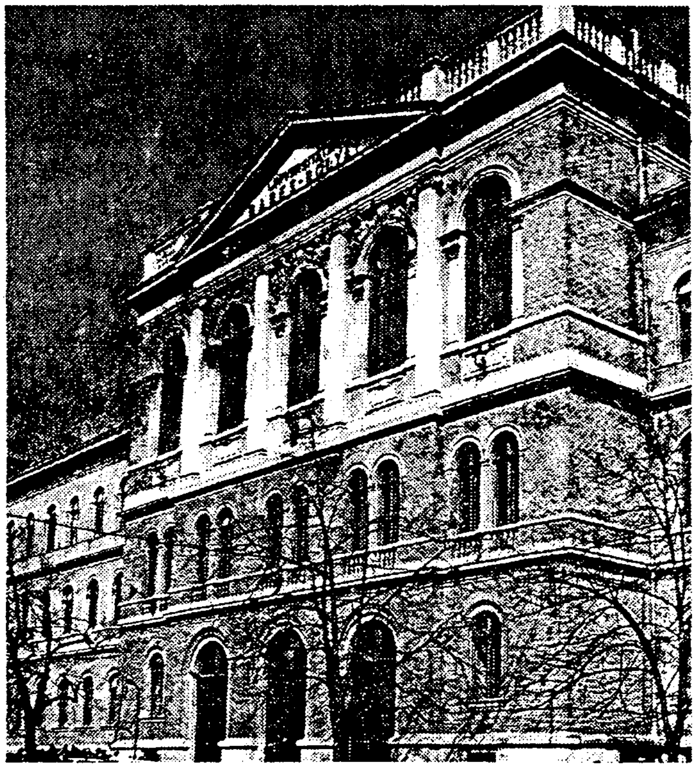
BPU-3

3rd GENERAL CONFERENCE OF THE BALKAN PHYSICAL UNION



2-5 September, 1997
CLUJ-NAPOCA, ROMANIA

PROGRAMME
AND
ABSTRACTS

2P-012

CHEMI-IONIZATION AND CHEMI-RECOMBINATION RATE COEFFICIENTS FOR STELLAR ATMOSPHERES CONDITIONS

A.A. Mihajlov[1,2]M.S. Dimitrijević[2], Lj.M.Ignjatović[1], M.M. Vasiljević[1]

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[2] Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia, Yugoslavia

In several precedent articles (see Ref. 1 and references therein) a semiclassical theory for the chemi-ionization processes during $A^*(n)$ and A slow collisions and the inverse chemi-recombination processes

$$A^*(n) + A \Longleftrightarrow e + A_2^+$$

$$A^*(n) + A \Longleftrightarrow e + \begin{cases} A^+ + A \\ A + A^+ \end{cases}$$

has been developed. This theory is correct for sufficiently large principal quantum number n. Such processes have an important role in atmospheres of helium rich white dwarfs (A = He). They are as well of interest for research of Solar atmospheres (A = H). We present here the rate coefficients for these processes, calculated with the help of one modification of earlier developed theory.

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2P-013

ELECTRON-IMPACT WIDTHS FOR Sr III LINES

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Serbia, Yugoslavia

The electron-emitter-absorber collisions are cause of the main pressure broadening mechanism in atmospheres of hot stars, Stark broadening. Consequently, the knowledge of the Stark broadening parameters is needed for the stellar atmosphere investigations and modeling. Also, Stark broadening data are needed for laboratory plasma investigations and diagnostic.

Here we present Stark widths for six $4s - 4p$ transitions of Sr III calculated by using the modified semiempirical approach (see Refs. 1,2 and reference therein) and jK coupling approximation.

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The Institute of Physics

3RD INTERNATIONAL CONFERENCE
ON

SPECTRAL LINE SHAPES

IMPERIAL COLLEGE, LONDON

13 - 17 SEPTEMBER 1976

Paper 60

STARK BROADENING OF DOUBLY IONIZED CHLORINE LINES

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A pulsed low pressure arc was the source of plasma used to measure, on a shot to-shot bases, profiles of eight doubly ionized chlorine lines. An electron density of 5.8×10^{16} cm^{-3} was determined by laser interferometry while electron temperature of 24200 K was measured from Bolzmann plot of relative intensities of C1 III lines. The experimental C1 III Stark profile full halfwidths in Å units are given in Table 1. For the same experimental condition two sets of theoretical data were calculated and are also given in table. Under W_{thB} are introduced results for the line widths according to the theory of Baranger 1962 with hyperbolic perturber-path trajectories while the results obtained from the combination of Baranger's approach with GBKO straight perturber path approximation for high perturber velocities (Cooper and Oertal 1967 and 1968) are introduced under W_{thCO}.

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Multiplet	λ (Å)	W_m (Å)	W_{thB} (Å)	W_{thCO} (Å)
$^4P-^4D^o(1)$	3602.1	0.10_6	0.097	0.056
	3612.8	0.10_3	0.097	0.056
	3657.0	0.10_3	0.097	0.056
$^4P-^4P^o(2)$	3283.4	0.09_7	0.085	0.049
	3340.4	0.10_0	0.085	0.049
$^2P^2-^2D^o(5)$	3748.8	0.10_8	0.092	0.053
$^2D-^2D^o(11)$	3393.0	0.08_5	0.097	0.057
	3393.4	0.08_1	0.097	0.057

II Југословенски семинар о атомској физици 6/II

[illegible] 1981

ŠTARKOVO ŠIRENJE JONSKIH LINIJA U SUDARNOJ APROKSIMACIJI

M.S. Dimitrijević

Danas su poznati različiti teorijski prilazi za procenu Štarkovih parametara spektralnih linija. Većina od njih zahteva znatan napor da bi se izračunao pojedinačni profil. Ponekad, naročito kod višestruko jonizovanih atoma, nema dovoljno podataka o strukturi spektra za detaljnije proračune. Osim toga za rešavanje pojedinih problema, kao što je na primer transfer zračenja kroz stelarnu plazmu, potrebna je procena većeg broja profila spektralnih linija. U takvim slučajevima postoji potreba za jednostavnijim prilazom koji bi pružao dobru usrednjenu tačnost.

U ovom izlaganju prikazaće se aproksimativan prilaz problemu Štarkovog širenja jonskih linija, razvijen na bazi sudarne aproksimacije uvodjenjem empirijskih vrednosti za Gaunt faktore[1-3]. Izvršeno je uporedjenje teorijskih rezultata, sa svim eksperimentalnim rezultatima za dvostruko i trostruko jonizovane atome, kao i sa izvesnim brojem rezultata za jednostruko jonizovane atome. Uporedjenje je izvršeno i sa različitim teorijskim prilazima a razmatra se i primenljivost metoda za viša stanja jonizacije.

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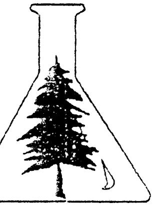

CO_2 O_3

II СИМПОЗИЈУМ ХЕМИЈА И ЗАШТИТА ЖИВОТНЕ СРЕДИНЕ

II SYMPOSIUM ON CHEMISTRY AND THE ENVIRONMENT

ИЗВОДИ РАДОВА - ABSTRACTS

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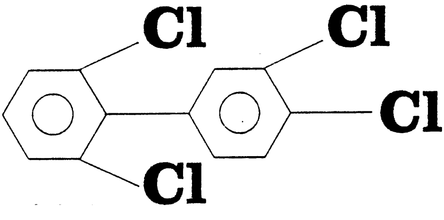

9. - 13. јуна 1993. Врњачка Бања
9. - 13. june 1993. Vrnjacka Banja

Српско хемијско друштво, уз сарадњу
Хемијског друштва Црне Горе
Serbian Chemical Society with the cooperation
of the Montenegrin Chemical Society

I-2

II. симпозијум "Хемија и заштита
животне средине", В. Бања. 1993.

JEDNA POLARIMETRIJSKA METODA MERENJA RELATIVNE ZAMUĆENOSTI ZEMLJINE ATMOSFERE

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Zemljina atmosfera zamućena aerosolima smanjuje intenzitet upadnog, a povećava intenzitet rasutog zračenja neba, unoseći na taj način znatne promene u fizičke osobine zračenja koje potiče od čiste, nezamućene atmosfere. Merenjem promenjenih fizičkih osobina zračenja mogu se dobiti podaci o stepenu zamućenosti Zemljine atmosfere. Jedan od mogućih načina procene stepena zamućenosti atmosfere zasniva se na polarimetrijskim merenjima zračenja vedrog neba.

Poznato je da je rasejana svetlost u Zemljinoj atmosferi polarizovana. Stepen polarizacije rasejane svetlosti u idealnoj atmosferi (bez aerosola) može se opisati Rayleighovom formulom:

$$P_r = sin^2\Theta/(1 + sin^2\Theta) \qquad (1)$$

Stepen polarizacije rasute svetlosti (P_r) zavisi samo od ugla rasejanja (Θ). Za $\Theta = 90^0$ stepen polarizacije postiže maksimalnu vrednost $P_r = 1$.

U realnoj atmosferi nikad nisu ispunjeni uslovi pod kojima važi gornja formula, tako da je maksimalna vrednost polarizacije uvek manja od 1. Iz radova drugih istraživača (npr. Coulson, 1974, ili Takashime i dr., 1974) vidi se da stepen polarizacije svetlosti rasute u realnoj atmosferi zavisi od talasne dužine zračenja (λ), od albeda (A), od optičke debljine molekularnog sloja atmosfere (τ) i od zamućenosti atmosfere (količine aerosola u atmosferi). Stepen polarizacije je složena funkcija ovih parametara i teško je pratiti njihov uticaj na osnovu modeliranja atmosfere. Medjutim, zna se da sa povećanjem stepena zamućenosti atmosfere opada stepen polarizacije rasute svetlosti u njoj. Prema tome, stepen polarizacije može biti dobar indikator, odnosno kvalitativni, a u relativnim merenjima i kvantitativni pokazatelj stepena zamućenosti atmosfere u raznim trenucima vremena ili na raznim mestima. Povoljna je okolnost da zamućenost atmosfere najviše utiče na maksimalnu vrednost merene polarizacije koja se zbog toga menja u veoma širokim granicama. U slučaju malog stepena zamućenosti atmosfere i u nekim granicama ugla rasejanja ($30^0 < \Theta < 150^0$), formula (1) relativno dobro prati oblik krive stepena merene polarizacije u realnoj atmosferi u funkciji ugla rasejanja. Medjutim, pomenuta ograničenost važenja te formule u realnoj atmosferi nameće izvesnu opreznost pri njenom korišćenju za niske vrednosti maksimalnog stepena merene polarizacije.

Da bi se u nekom datom merenju polarizacije neba odvojio efekat zamućenosti u atmosferi od polarizacije nezamućene (idealno čiste) atmosfere korisno je bar približno proceniti odgovarajuće parametre (λ, A, τ) i rezultujući stepen polarizacije nezamućene atmosfere.

Radi dobijanja što potpunijeg uvida u stanje polarizacije neba sa jedne strane i što jednostavnijeg načina izvodjenja merenja sa druge strane, razradjena je jedna optimalna procedura merenja. Merenje se sastoji iz dve serije. Prva serija sadrži merene tačke u vertikali Sunca na raznim zenitskim daljinama. Druga serija se meri na velikom krugu oko Sunca i sadrži parove tačaka koje se nalaze u preseku velikog kruga oko Sunca sa almukantarima odredjenih zenitskih daljina. Povoljne osobine ovakvog rasporeda tačaka su: 1) Stalne zenitske daljine tačaka što omogućuje neposredno usrednjenje većeg broja odgovarajućih podataka. 2) Dovoljan broj tačaka na elongaciji 90^0 od Sunca (tačke maksimalne polarizacije) što omogućuje najjednostavniju interpretaciju posmatranih podataka. 3) Merenja u vertikali Sunca pojednostavljuje redukciju. 4) Moguća je konstrukcija instrumenta koja omogućuje da se sve tačke posmatraju bez korišćenja azimutalne skale.

Za merenje polarizacije zračenja dnevnog neba izradjena su dva laka, prenosna instrumenta. Daćemo opis jednog od njih. Taj instrument je izradjen od jedne meteorske kamere u kojoj se na dnu kratkog tubusa bez objektiva nalazi fotootpornik koji se izlaže zračenju neba kroz obrtni polaroid. Pravac posmatranja kontroliše se postojećim skalama zenitske daljine i azimuta, ugradjenom libelom i trostranom prizmom čije baze materijalizuju ravan normalnu na pravac posmatranja.

Merenja koja smo vršili na više mesta u Jugoslaviji ukazuju na veliku osetljivost polarimetrijske metode na promenu zamućenosti Zemljine atmosfere (Vince i Kubičela, 1981). Smatramo da je ova metoda lako primenljiva i pogodna za dugoročnu kontrolu kvaliteta atmosfere u velikim razmerama tj. po celoj efektivnoj visini atmosfere i u horizontalnim razmerama istog reda veličine. To su razmere u kojima bi bilo pogodno dugoročno kontrolisati stanje zagadjenosti atmosfere iznad nekog većeg naseljenog mesta.

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A POLARIMETRIC METHOD FOR MEASUREMENT OF RELATIVE TURBIDITY OF THE EARTH'S ATMOSPHERE

I. Vince, A. Kubičela and M.S. Dimitrijević

On the basis of the known theoretical and empirical facts about optical polarization of clear sky a method for measurement of relative atmospheric turbidity has been developed. A portable instrument with light-dependent resistors as radiation sensors for day-sky polarization measurements was designed and constructed. Applicability and efficiency of the proposed method has benn estimated and proposed for long series and large-scale monitoring of atmospheric turbidity.

UNIVERSITÄT SALZBURG

Institut für Mineralogie

2. WORKSHOP ÜBER DEN GEOCHEMISCHEN NACHWEIS DER SONNEN NEUTRINOS MIT HILFE DES ^{205}TI-LOREX PROJEKTES

PROGRAMM UND ABSTRACTBUCH

29. und 30.April 1994, SALZBURG

AUSTRIA

SPECTRAL LINE WIDTH AND SHIFT INVESTIGATION FOR SOLAR PLASMA DIAGNOSTIC

Milan S.Dimitrijević and Ištvan Vince
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For the purpose of calculating neutrino fluxes the work on the testing and improving of Solar model is significant. The energy generated in the Solar core is transported through the subphotospheric layers and the photosphere. Therefore, the behavior of photospheric lines has an indirect connection with energy production in the core and its transport through the interior of the Sun. Magnetohydrodynamical and thermal modulation of the internal structure of the Sun can be manifested in photosphere, among others, as change in photospheric line profiles.

In order to test and develop a reliable solar model among other data we need as well the data on profiles and behavior of subphotospheric and photospheric spectral lines. Reliable Stark broadening data are needed for the determination of chemical abundances of elements from equivalent widths of absorption lines and for the estimation of the radiative transfer through the solar plasmas, especially in subphotospheric layers as well as for opacity calculations. In such a case data for especially large numbers of lines are needed. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level and consequently, Stark broadening contribution may become significant even in the Solar spectrum.

In this contribution, the work on Belgrade Observatory concerning Solar spectral line observations and theoretical Stark broadening calculations for photospheric and subphotospheric spectral lines will be reviewed. The spectral lines observations show a variability on time scales: from minutes to years and decades. The variations in the range from minutes to days (short-term variations) relate to the convective motions (granulation and supergranulation) and to the solar oscillations. The variations lasting for years and decades (long-term variations) are connected with dynamical and thermal modulation of the internal layers and are also linked to the evolution of magnetic fields over a 11-year activity cycle of the Sun. Since the question of correlation of spectral line parameters with the solar activity has not been finally solved, a long-term program of full solar disk observations of photospheric spectral lines was initiated in 1986 at Belgrade Astronomical Observatory for the study of variations of equivalent widths, half-widths and central residual intensities of spectral lines during the 22nd solar activity cycle. Routine observations are in progress since 1987. The observations are performed with the equatorial solar Litrow-type spectrograph of 9 m effective focal length and dispersion about 70 mm/nm in 5th order, with a Baush & Lomb replica grating. Using three flat mirrors an unimaged beam of sunlight is fed through the 100-150 microns wide entrance slit to give the solar integrated flux spectrum. For this purpose the spectrograph was converted into a scanning monochromator in 1986. The scanning is realized by optically shifting the image of the spectrum with respect to the exit slit. The choice of the spectral lines to be observed was, in general, governed by several criteria according to which a list of 31 spectral lines has been compiled. The first results for 10 spectral lines observed in period from 1987-1990 show that some equivalent widths are constant and some change progressively.

Here is presented also a review of semiclassical calculations of Stark broadening parameters and the comparison of different semiclassical procedures is discussed, as well as the agreement with critically selected experimental data and more sophisticated, close coupling calculations. Approximate methods for the calculation of Stark broadening parameters, useful especially in such astrophysical problems where large scale calculations and analyses must be performed and where only a good average accuracy is expected, have been discussed as well.

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BAZA ASTRONOMSKIH PODATAKA
ASTRONOMSKE OPSERVATORIJE U BEOGRADU
THE ASTRONOMICAL DATA BASE OF
ASTRONOMICAL OBSERVATORY IN BELGRADE

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Sadržaj - *U radu se daje opis Baze astronomskih podataka Astronomske opservatorije u Beogradu (ADBAOB). Baza je još u fazi kreiranja, a trebala bi da sadrži podatke koji bi jednako mogli koristiti astronomima i fizičarima.*

Abstract - *In this paper the description of the Astronomical Data Bases of Astronomical Observatory in Belgrade (ADBAOB) is given. The base is in the status of creation, and it will include data which are useful to astronomers as well as to physicists.*

1. UVOD

Analiza zvezdanih spektara daje veliki broj informacija o ovim objektima, kao što su: hemijska zastupljenost elemenata, fizički procesi u atmosferama, prostorna raspodela aktivnih regiona, jačina magnetnog polja, itd. Da bi se došlo do pouzdanih informacija, potrebno je imati standardan model zvezdane atmosfere, a u taj model uključiti veliki broj pouzdanih atomskih podataka (vidi npr. [1]). Između ostalog za modeliranje linija iz zvezdane atmosfere su neophodni parametri elektronskog i jonskog sudarnog, prirodnog i van der Valsovog širenja. Zahvaljujući dugogodišnjem radu saradnika Astronomske opservatorije u Beogradu na problematici širenja linije usled sudara sa elektronima i jonima, ovi podaci su izračunati za veliki broj emitera, koji se upotrebljavaju ne samo za modeliranje astrofizičke, nego i laboratorijske plazme (vidi npr. [2-4]). Korisnici ovakvih podataka (posebno naše kolege iz inostranstva) su ukazali na potrebu da ovi podaci budu preneseni u digitalnu formu i da takvi, pogodniji za upotrebu, budu dostupni preko interneta. S obzirmo na kvalitet podataka ponuđeno nam je da ova baza bude vidljiva sa www site-ova drugih velikih (svetskih) baza kao što su WALD (sedište u Austriji, vidi [5]) i baze međunarodne atomske agencije (ALADIN). Ovde ćemo dati kratak opis buduće baze astronomskih podataka Astronomske opservatorije u Beogradu (skraćeno ADBAOB) čije kreiranje je u toku.

2. SADRŽAJ BAZE PODATAKA

Baza treba da sadrži do sada najkompletniji set podataka o parametrima širenja usled sudara elektrona i jona sa emiterima u plazmi. Podaci koje će sadržati dobijeni su teorijski i eksperimentalno. Teorijski podaci su dobijeni korišćenjem dva metoda:

1. *Semiklasični perturbacioni metod* [3,6,7]. Do sada su izračunati podaci za sledeće emitere (vidi [3]): 79 He, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 12 B III, 23 Al III, 10 Sc III, 27 Ba III, 32 Y III, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 19 O V, 30 N V, 25 C V, 51 P V, 33 V V, 30 O VI, 21 S VI, 10 O VII, 10 F VII, 20 Ne VIII, 4 Ca IX, 8 Na IX, 48 Ca X, 7 Al XI, 4 Si XI, Si XII, 26 V XIII, takođe za pojedinačne linija parametri Štarkovog širenja su izračunati i kod sledećih elemenata: F, Ga II, Ga III, Cl, Br, I, Cu, Hg II, N III, F V S IV.

2. *Modifikovano semiempirijski metod* [4,8,9]. Ovaj metod je korišćen kod sledećih emitera: Sc II, Ti II, Mn II, Fe II, Bi II, Pt II, Zn II, Cd II, As II, Br II, Sb II, I II, Xe II, Y II, Zr II, La II, S III, Be III, B III, C III, N III, O III, F III, Ne III, Na III, Al III, Si III, P III, S III, Cl III, Ar III, Mg III, Mn III, Ga III, Ge III, As III, Se III, La III, Zn III, Cu IV, B IV, C IV, N IV, O IV, Ne IV, Mg IV, Si IV, P IV, S IV, Cl IV, Ar IV, Ge IV, C V, O V, F V, Ne V, Al V, Si V, N VI, F VI, Ne VI, P VI i Cl VI.

3. ORGANIZACIJA BAZE

Baza će biti smeštena na serveru Astronomske opservatorije, a pristup će se ostvarivati preko interneta tokom 24 časa. Šema organizacije prikazana je na Sl. 1. Astronomska baza podataka ima za cilj da zainteresovanim korisnicima omogući da brzo i lako, preko interneta, dođu do podatka koji su u njoj sadržani. Sistem se sastoji iz sledećih delova (vidi Sl. 1):

- BAZA
- "HTTP daemon" (www server);
- "interface" za upravljanje bazom; Ukratko rad Baze se može opisati na sledeći način: HTTPD, kao što je poznato, "osluškuje" zahteve na Internetu i kada ih primi, prosledi zahtev interface-u za upravljaće bazom, koji stvara

odgovarajući upit na osnovu koga se pretražuje Baza. Posle toga se izveštaj šalje, u pogodnom (HTML) formatu, nazad HTTPD-u, koji dalje prosleđuje odgovor korisniku koji je uputio zahtev.

Upit koji će korisnici popunjavati davaće mogućnost da se podaci distribuiraju u dva oblika; podaci koji su potrebni fizičarima za modeliranje laboratrijske plazme i podaci potrebni astronomima za modeliranje zvezdane plazme.

Planirano je da ADBAOB koja će sadržati gore opisane podatke bude puštena u rad krajem 1998. godine. a takođe se [illegible] pre svega spektrima aktivnih galaktičkih jezgara i Sunca.

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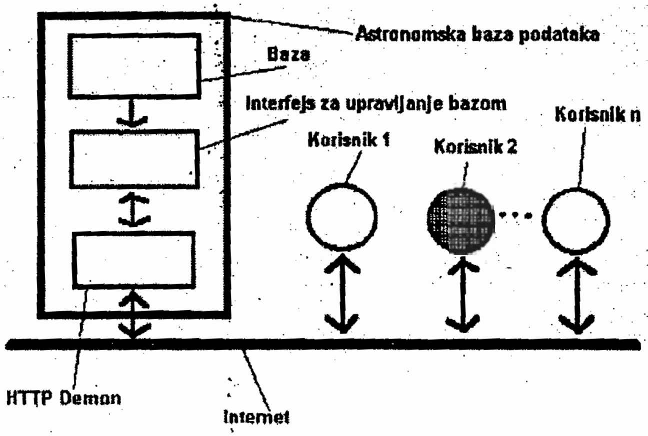

Sl. 0: Dijagram pokazuje lokalnu strukturu baze i način pristupa podacima.

[illegible] 94.

САВЈЕТОВАЊЕ "ИНОСТ"

ЗАШТИТА ИНДУСТРИЈСКЕ СВОЈИНЕ, ТРАНСФЕР И НОВЕ ТЕХНОЛОГИЈЕ У СРПСКИМ ЗЕМЉАМА

Бања Лука, 27 - 28. маја 1994. године

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ТЕСЛИНО НАУЧНО НАСЛЕЂЕ

У суревњивости између науке и технике - ко пресудније утиче на развој цивилизације, дело Николе Тесле симболизује њихову међузависност и суштинску повезаност. Бројни технички проналасци који су Тесли донели светску славу, претходно су пролазили кроз његову духовну радионицу научника. Имао је изузетну способност да види предмете својих мисли као материјализоване објекте. Све конструкције пре него их сагради од материјала, он је данима, месецима и годинама носио у глави, постављене на новим принципима и дизајниране до најситнијих детаља; тако замишљена машина радила је у Теслиној глави, он јој је, по уоченој потреби, мењао делове и усавршавао је. По томе је био јединствен у историји технике и један од ретких у историји науке.

Комплементарност научне мисли и инжењерске вештине најубедљивије се може показати на примеру Теслиног рада на вишефазном систему наизменичних струја. Теслину идеју да се може унапредити рад Грамове машине употребом наизменичне струје и избацивањем комутатора, његов професор физике Пешл на Техничкој великој школи у Грацу детаљно анализира читав један школски час и на крају показује да је неостварива, да су се том идејом пре Тесле бавили многи научници без успеха; да би њено остварење значило исто што и једну сталну привлачну силу, као што је тежа, претворити у обртну силу (О' Нил, 1993). Тесла је ућуткан, али не одустаје да трага за решењем које је ауторитативно одбачено као перпетуум мобиле. Као и у случају ''Њутнове јабуке'' и о Теслином открићу обртног магнетног поља остала је романтична прича његовог биографа Џона О' Нила, да је Тесли та идеја, са јасним обрисима иднукционог мотора, синула једног предвечерја у Будимпешти 1883.године, при заласку сунца, док је шетао парком са пријатељем Сигетијем и рецитовао му Гетеове стихове.

После низа година и низа перипетија, Тесла добија лабораторију у Јужној петој авенији у Њујорку, и великом брзином гради динамомашине за производњу наизменичне струје, моторе за добијање механичког рада из тих струја, трансформаторе и друге уређаје, преносећи директно из главе на папир све елементе њихових конструкција, укључујући и димензије. И, коначно, 12. октобра 1887. године, подноси Америчком уреду за патенте знамениту ''омнибус пријаву'', на основу које добија 7 патената који заокружују његов вишефазни систем наизменичних струја. Тесла научник разрадио је и математичку теорију за свој систем наизменичних струја, обухватајући њоме не само машине које раде са стандардном учестаношћу од 60 Hz (Цверава, 1974, већ и за струје више и ниже учестаности. Значај Теслиног открића брзо је запажен и 15 дана после објављивања његових патената, 16 маја 1888. године, он добија позив да одржи предавање о вишефазном систему наизменичних струја у Америчком институту електроинжењера.

Ова серија Теслиних патената и ово Теслино предавање постали су класика електротехнике, што је дало повода Теслином биографу да 1944. године изведе закључак: "Од тада па до данас ништа ново, макар и приближно по својој величини, није постигнуто у електротехници.".

Дали смо доста простора опису Теслиног рада на вишефазном систему наизменичних струја, јер је та серија проналазака у ствари Теслина оставштина за будућност.

И сам Тесла, кога су с разлогом звали "песник науке", дао је директан одговор на питање који му је његов проналазак најдражи. Рекао је: обртно магнетно поље и индукциони мотор. "Увек сам био богат идејама - каже Тесла - али ни један други проналазак, ма колико да је био велики, није ми био драг као тај први."

Ове Теслине речи са емотивним набојем добијају дубљи смисао у једном његовом тексту објављеном 9. новембра 1929. године у Њујорк Тајмсу. Све чега се лаћао, Тесла је завршавао и није имао обичај да се осврће на оно што је створио и дао јавности на коришћење. Тако, више од 30 година није говорио о свом полифазном систему и индукционом мотору. Али га је једно саопштење из "Њујорк тајмса", у коме је уздизан Едисон, а његово дело омаловажавано, присилило да напише:

"Едисонов систем за последњих 25 година потпуно је замењен мојим системом, заснованим на мом обртном магнетном пољу... Већи део суме од 60 милијарди долара која, по признању председника Хувера, представља вредност електричног пословања (у САД), односи се на мој систем и његов утицај на индустрије електричног осветљења и друге... Оно што сам ја дао представља нов и трајан додатак човечијем знању. Можда ће и моја конструкција индукционог мотора, као што је случај са Едисоновом сијалицом, у току непрекидне еволуције технике пасти у заборав, али ће моје обртно магнетно поље, са свима његовим изванредним феноменима и манифестацијама силе, живети докле год буде било науке."(Бокшан, 1946)

Поред Тесле и други научни ауторитети сматрају да је обртно магнетно поље његов главни допринос науци. Тако нобеловац Е.Х. Армстронг, проналазач електронског осцилатора и један од најпознатијих стручњака на пољу радиотехнике каже: "Проналасци Николе Тесле на пољу вишефазних струја и његов индукциони мотор били би довољни да му овековече славу... О његовом доцнијем делу на пољу струја високе фреквенције и високог напона, осећам се позваним да кажем своје мишљење, јер је оно извршило највећи утицај на мој развитак и опредељење у животу... Верујем да ће свет дуго чекати док се не појави геније који би могао бити такмац Николи Тесли у погледу његових великих остварених дела и његове имагинације." (Матић, 1989)

Прва велика инсталација Теслиног вишефазног система наизменичних струја 1896. године на Нијагари била је највећи догађај у дотадашњој историји инжењерства.

Теслин вишефазни систем наизменичних струја, и после 100 година од увођења, није ништа изгубио на значењу, као темељ наше цивилизације и средство за задовољење наших свакодневних потреба, што је В.А. Беренд сликовито изразио речима: да би стали точкови наше индустрије и саобраћаја, да би нам градови били неосветљени, а фабрике чамиле мртве и доконе, кад бисмо из њих искључили резултате Теслиног рада.

Деветнаести век је овај проналазак предао двадесетом, а двадесети се спрема да га преда двадесет првом.

Поред вишефазног система наизменичних струја, у Теслине велике доприносе развоју науке и технике спадају његови проналасци из области струја високих фреквенција и високих напона и из области радиотехнике, бежичне телеграфије и телеаутоматике.

Ништа мање атрактиван био би списак његових узгредних проналазака, за које није тражио патентну заштиту, а данас представљају симболе нашег времена (антена, радар, даљински управљач, робот, ракета, телефакс и сл.).

Проживео је живот срећног човека, јер се од 17. године непрекидно бавио послом за који је био предодређен, више од 70 година, свестан да припада реду оних "изузетно повлашћених људи, без којих би људска раса, у општој борби за опстанак... нестала с лица земље." За себе Тесла каже да је за све време осећао чар уживања што своје духовне силе искоришћује за стваралачки рад и да је његов живот зато "кроз дуги низ година протекао у непрекидном заносу".

Био је неуморан радник, који је "размишљању посветио све своје будне часове". Увек је тврдио да ноћу не спава више од 2 сата. Одлазио је на починак у 5 ујутру. Једном у години, признавао је, спавао би 5 сати, услед чега би, наводно, прикупио огромну залиху енергије. Није могао да разуме зашто и други нису у стању да поднесу оне напоре које је он подносио. Као власник фирме био је готов да плати необично велику надницу сваком раднику који би био вољан да остане с њим на раду, али никад није захтевао такав рад који би прелазио разумну меру. Он сам, пак, једном је радио непрекидно 84 сата, без сна и одмора, да би инсталирао један приспели уређај важан за његове експерименте.

На прелазу између два века он је био медијска личност, и више од тога. По речима професора Војина Поповића, Тесла је био личност број један у САД пуних петнаест година, од 1887. до 1902. године, о чијим су достигнућима новине писале тако рећи свакодневно, доносећи вести о томе на чему ради и интервјуе с Теслом на најразличитије теме, укључујући футуристичке.

У електротехници и науци о електрицитету могао је оно што није могао нико ни пре ни после њега. Теслин трансформатор је у погледу производења електричних осцилација био исто толико револуционаран за заснивање нове цивилизације базиране на коришћењу електрицитета, колико и барут у историји ратовања.

Са оптимизмом је гледао на будућност човечанства и живот народа у миру и достојанству. Први је дошао на идеју о светским и интерпланетарним комуникацијама. Видео је човека како изграђује васиону према својим жељама и писао са песничким надахнућем да човек располаже знањем које му омогућава да се умеша у космичке појаве.

Тесла је изашао као победник у "рату струја", једносмерне и наизменичне.

Савладао је опозицију своме систему таквих ауторитета као што су били Едисон и Лорд Келвин, који је на крају рекао: "Тесла је више допринео науци о елктрицитету него и један човек пре њега".

Имао је ретку способност да предвиди практичну примену проналаска.

Један новинар рекао је, у вези с тим, на новинарски начин: "Његова достигнућа изгледају као сан пијаног Бога", што је Теслин биограф О' Нил исказао прецизније: "Чак ни у најбујнијој машти својих поклоника нису се стари богови упуштали у циновске подухвате светских размера као што је Тесла покушао, и у томе успео. Ценимо ли га по његовим надама, по његовим сновима и његовим достигнућима, он је раван боговима с Олимпа, и Грци би му нућима новине писале тако рећи свакодневно, доносећи вести о томе на чему ради и интервјуе с Теслом на најразличитије теме, укључујући футуристичке.

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Живео је у херојско проналазачко доба, када се сматрало да је све пронађено, због чега се и у једној Енглеској, колевци прве индустријске револуције, говорило у парламенту о потреби укидања уреда за патенте. Тесла је на ту тему писао: ”Погрешан је утисак да се све већим напретком могућности за проналаске исцрпљују. У ствари, сасвим је супротно. Што више знамо, то смо веће незналице у апсолутном смислу, јер једино просвећивањем постајемо свесни своје ограничености.”

Дан после Теслине смрти, 8. јануара 1943. године, ”Њујорк тајмс” је писао да се и од мртвог Тесле очекују чудеса.

Такав Тесла, принц из бајке о науци, потекао је из једног старог народа велике културе. Данас, кад нам је тешко, падају нам као мелем на душу Теслине речи о његовом проналазачком раду изговорене у Београду 2. јуна 1892. године: ”Ако се моје наде испуне, најслађа мисао биће ми та, да је то дело једног Србина...”.

Један Србин, први је из Њујорка проповедао и градио светски информациони систем, кад су му се други подсмевали и говорили да је сањар. Он је у светском информационом систему и бежичном преносу електричне снаге видео многе добробити за човечанство. Као једно од својих последњих ”запрепашћујућих” открића, Тесла је наводио да осети неки необичан и неописив ”космички бол” кад неко њега и некога коме је привржен - увреди. Можемо само да претпостављамо какав би био његов бол данас, кад кроз светски информациони систем, коме је он постављао темеље, теку тешке клевете и лажи о његовом народу.

Како је Теслин народ гледао на Теслу чуло се 28. маја 1936. године, када је на Коларчевом народном универзитету одржана Свечана академија посвећена 80. годишњици рођења Николе Тесле. У реферату председника Управе удружења југословенских инжењера и архитеката, чији је почасни члан био Никола Тесла, речено је, између осталог, да се Теслини проналасци граниче са чудотворством и да наши људи из народа с правом веле: ”Тесла је, Бог да прости, највећи човек после Христа.”, и да је по оној Његошевој: ”У великим народима генију се гнездо вије” наш народ на овом пољу, технике, израстао на степен великог народа (***, 1936).

Дело Николе Тесле читалачкој публици у Србији први је представио 1894. године Ђорђе М. Станојевић у форми књиге под насловом: ”Никола Тесла и његова открића”. Књига садржи све до тада објављене Теслине патенте и предавања која је држао у САД и Европи.

У раду на овој књизи проф. Станојевић и Тесла су непосредно сарађивали, тако што је Тесла слао, поред најновијих патената и текстова, клишеа, слике и шеме за књигу, што је за техничке могућности наше издавачке делатности тога времена много значило. То је и до данашњег дана једна од најбоље опремљених техничких књига на нашем језику и добро је учинила САНУ што је објавила њен репринт 1976. године, поводом 120. годишњице од рођења Николе Тесле.

Станојевићева књига о Тесли појавила се пред српским читаоцима исте године (1894.) када је у САД објављена књига ауторитативног Т.К. Мартина под насловом ”Проналасци, истраживања и списи Николе Тесле”, за коју је нобеловац Армстронг рекао да је извршила одлучујући утицај на њега и његову генерацију младих људи заинтересованих за науку.

Ђорђе М. Станојевић био је по струци физичар, астрофизичар и метеоролог, у време Теслиног боравка у Београду професор физике и механике на Војној академији, а касније ректор Београдског универзитета и директор Астрономске опсерваторије у Београду, што истичемо с посебним задовољством.

Он је наш први астрофизичар, који је у 19. веку објављивао научне радове о Сунцу у часопису Француске академије наука, наш први стручњак који се квалификовано бавио популаризацијом науке у нашем народу, настојећи да јавност овлада основним појмовима и сазнањима науке и технике онога времена. За разлику од њега, Орфелин, Доситеј и Атанасије Стојковић, деловали су, раније, пре свега с циљем да у народу сузбију сујеверје и друге заблуде.

Као студент треће године Станојевић пише рад под називом: "Звездано небо независне Србије" (1880.г.), у коме најављује кредо популаризатора науке кроз реченицу која гласи: "Ништа није грешније него знати неку истину а не хтети је казати и другоме, који је не зна и у свом незнању лута тамо амо, машајући се често и за највећу погрешку." (Трифуновић и Димић, 1976)

Из сарадње на књизи о Теслиним патентима развило се пријатељство између Тесле и Станојевића, што је сигурно утицало и на то да се у Београду приступи одмах, 1893.г., увођењу електричног, а не плинског, осветљења и да се електрификација Србије постави такође на Теслиним основама за шта је највише заслужан Станојевић, градитељ наших првих централа, човек који је Београду подарио светлост.

Запитајмо се шта данас кочи наше научнике у земљи и свету да сарађују по моделу: Никола Тесла - Ђорђе Станојевић ? Данас имамо телефакс, а Теслине пошиљке Станојевићу путовале су преко океана бродом.

Од раније нам је био познат Теслин рад на упућивању сигнала на Марс, у нади да постоји живот на тој и другим планетама. Како је спуштање "Викинга 1" на планету Марс, 1976.г., коинцидирало с прославом 120. годишњице рођења Николе Тесле, директор НАСА је у време одржавања Симпозијума о Николи Тесли у Загребу одржао конференцију за штампу на којој су приказани први снимци Марса. Том приликом приказани су и исечци из америчке штампе с почетка 20. века у којима је писано о Теслиним замислима интерпланетарне комуникације и његовом упућивању сигнала на Марс.

У часопису "Electrical exxperimenter" Тесла је 1919. године објавио три чланка под заједничким насловом: "Ротација месеца". Томић и Јовановић (1993) наводе да Теслине закључке из ових чланака потврђује савремена наука, међу којима и радови Павла Савића о пореклу ротације небеских тела, из 1965. године.

Астрономи су се Тесли одужили на тај начин што је његово име добио један кратер на другој (невидљивој) страни Месеца (који је 29.07.1965.године снимила совјетска летилица "ЗОНД-3") и мала планета под бројем 2244 коју је открио Милорад Б. Протић, са Астрономске опсерваторије у Београду.

Теслино име данас носи и јединица мере за магнетну индукцију, као и међународна награда за значајне доприносе на пољу производње и коришћења електричне енергије

Америчко удружење електроинжењера сврстало је Теслу на седмо место међу десет највећих, 1893. године. Сто година касније исто удружење ставило га је на пето место, иако се у међувремену листа знатно изменила новим великим именима савремене науке.

Ни педесет година после смрти Николе Тесле, наша наука још није започела систематско изучавање његовог дела и поред велике предности што се у Музеју Николе Тесле у Београду налази оригинална Теслина архивска грађа, која можда крије неку тајну. Ретке су наше стручне књиге о Тесли, нема га у наставним програмима, нити је збирка Теслиних патената публикована на српском језику.

Тесла није водио спорове са плагијаторима, већ је имао обичај да каже да не жали што га други поткрадају, већ што немају својих идеја.

Нико озбиљан у науци не оспорава Њутну ауторство три закона који носе његово име, и поред тога што су њихове формулације у међувремену кориговане у нијансама у односу на оригиналну верзију и што су "Њутнове једначине" за Њутнов други закон написали 50 година касније Ојлер и Маклорен, а не Њутн. Све се то покрива тврдњом да је "Њутн рекао оно што је битно", да нове формулације и математички еквивалент једнозначно следе из оригинала (Млађеновић, 1991).

Међутим, Теслин допринос развоју науке и појединих грана технике у неким енциклопедијама и књигама незаслужено се приписује другима, а најчешће Ферарису и Марконију (у случају обртног магнетног поља и радија) и поред необоривих Теслиних приоритетних права из патентних списа. После Теслине смрти научна јавност је дужна да заштити морална права Николе Тесле и његово научно наслеђе.

Година Николе Тесле (1993.) треба да нас инспирише да са наше стране урадимо што је потребно да се његово дело систематски изучава, да се у историји електротехнике и радиотехнике прикаже у правој светлости и да му се одају признања која заслужује.

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RESUMES DES COMMUNICATIONS INVITEES ET AFFICHES

ABSTRACTS OF INVITED AND CONTRIBUTED PAPERS

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2.16 ELECTRON-IMPACT BROADENING OF Cu IV LINES FROM AN ELECTRODYNAMIC MACROPARTICLES ACCELERATOR ARC PLASMA

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The electrodynamic accelerators of macroparticles enable the creation of extremely dense plasmas at relatively low temperatures. An example of such apparaturs (based on the conductor acceleration in the circuit's magnetic field) consists of an electrical power source and two parallel metal rails between which the macroparticle move (1). The circuit is closed by the electrical arc created between the rails. The arc plasma (formed by the evaporated metal foil through which the discharge is initiated) is accelerated by the magnetic field, and its hydrodynamic pressure accelerates the macroparticle- projectile.

Using a model method (2) of loss energy simulation on the boundary surfaces, we calculated arc macroparameters (e.g. arc lenght) and plasma characteristics (temperature, composition) for rectangular geometry. It is assumed, like in Ref.1, that the arc plasma is created by the evaporation of a Cu foil. Our results show that in the arc plasma electron density is 10^{17}- 5×10^{18}cm^{-3} in the arc tail and increase monotonically in the main arc part. The electron temperature vary from 1 to 5eV. The arc plasma contains mainly Cu III ions. However, Cu IV ions also present and their lines are more convenient for diagnostic purposes due to the less influence of selfabsorption. For such a reason, we performed also the calculation of electron-impact broadening parameters for selected Cu IV lines.

For the calculation, the modified semiempirical approach (3) has been used. Electron-impact full halfwidth W_{SEM} can be calculated from the following expression:

$$W_{SEM}= 2(2\pi\hbar/3m)^2(6m/\pi kT)^{1/2}N\Big\{\sum_{\substack{j,j'= \\ i,i',f,f'}}\Big[\vec{R}^2_{\ell_j,\ell_j+1}\tilde{g}(E/\Delta E_{\ell_j,\ell_j+1}) + $$

$$+ \vec{R}^2_{\ell_j,\ell_j-1}\tilde{g}(E/\Delta E_{\ell_j,\ell_j-1}) + \sum_{j'}(\vec{R}^2_{jj'})_{\Delta n\neq 0}\tilde{g}(3kTn_j^3/4Z^2E_H)\Big]\Big\},$$

$$\tilde{g}(x) = 0.7 - 1.1/Z + g(x),$$

$$\vec{R}^2_{\ell,\ell'} = (3n/2Z)^2 \left[\max(\ell,\ell')/(2\ell+1)\right] \left[n^2 - \max^2(\ell,\ell')\right]\phi^2,$$

$$\sum_{j'} \langle \vec{R}^2_{jj'} \rangle_{\Delta n \neq 0} = (3n_j/2Z)^2 (n_j^2 + 3\ell_j^2 + 3\ell_j + 11)/9.$$

Here, i and f designate initial and final energy levels, n is the effective principal quantum number, Z-1 is the ionic charge, ϕ the Bates and Damgaard factor (see e.g. Ref.3) and E = 3kT/2. Atomic energy level data are taken from Ref.4.

As an example of the results obtained, electron-impact full halfwidths for 4s^{3}F - 4p^{3}F and 4s^{3}F - 4p^{3}D Cu IV multiplets are given in Table 1. The results are presented for the standard electron density 10^{17}cm^{-3} (far arc plasma tail condition) but for higher densities across the arc plasma axis electron-impact width will be large.

Table 1. Electron-impact full halfwidths (W_{SEM}) for Cu IV lines for different temperatures (T) and at electron density 10^{17}cm^{-3}.

Ion	Transition wavelength [Å]	T[K]	W_{SEM}[Å]
Cu IV	4s^{3}F - 4p^{3}F 1422	10 000	1.47×10^{-2}
		20 000	1.04×10^{-2}
		30 000	8.49×10^{-3}
		50 000	6.58×10^{-3}
Cu IV	4s^{3}F - 4p^{3}D 1378	10 000	1.37×10^{-2}
		20 000	9.70×10^{-3}
		30 000	7.92×10^{-3}
		50 000	6.14×10^{-3}

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INFLUENCE OF ELECTRON COLLISIONS ON THE PROPAGATION OF GUIDED ELECTRON PLASMA WAVES ALONG THE CYLINDRICAL INTERFACE BETWEEN TWO PLASMAS

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The subject of guided electron plasma waves has attracted the interest of physicists and engineers since the late thirties, with varying motivations ranging from beam devices, plasma generation, microwave devices, plasma diagnostics, meteor trails and plasma resonance to plasma heating /1-9/.

The basic aim of the theory of plasma waves on plasma interfaces is to establish the dependence of wave number on frequency (or the phase, or dispersive characteristics of the wave) and to analyse wave attenuation as function of frequency.

Dissipative attenuation effects are generally believed to have little impact on the dispersive wave characteristics and are normally treated by perturbation methods.

The aim of the present paper is to determine the attenuation and phase coefficients (α and β) of guided electron plasma waves, propagating along a cylindrical interface between two plasmas, by the introduction of complex permittivities of plasmas:

$$\epsilon_p = \epsilon_{pr} - j\epsilon_{pi} = 1 - \frac{\omega_p^2}{\omega^2+\nu^2} - j\frac{\nu}{\omega}\frac{\omega_p^2}{\omega^2+\nu^2} \qquad (1)$$

where ω, ω_p and ν are the operating, plasma and electron frequency, respectively.

In the presence of electron collisions, guided electron plasma waves must attenuate /3,8/, and Z dependence of electromagnetic field must be given in the form $\exp(-jkz)$, where complex wave number k is given by

$$k = \beta - j\alpha \qquad (2)$$

The guided electron plasma waves are slow and we can assume

$$|\alpha + j\beta|^2 \gg |\omega^2\mu\epsilon| \qquad (3)$$

In this case, the dispersion relation of guided electron plasma waves is given by

$$\epsilon_{pin} = \epsilon_{pout}/[1 + 1/ka\, I_n(ka)K_n'(ka)] \qquad (4)$$

where a is radius of cylindrical interface, I_n is the modified Bessel function of the first kind, order n, K_n' is the first derivative of the modified Bessel function of the second kind, order n, with respect to the argument, ϵ_{pin} and ϵ_{pout} are the permittivities of the inner and outer plasma.

Furthermore, with $|ka|>1$ we can use the asymptotic expansions of the modified Bessel functions /10/:

$$I_n(z) = \frac{e^z}{(2\pi z)^{1/2}}\left[1 - \frac{4n^2-1}{8z} + \frac{(4n^2-1)(4n^2-9)}{2!(8z)^2} - \frac{(4n^2-1)(4n^2-9)(4n^2-25)}{3!(8z)^3} + \dots\right], \quad (|\arg z|<\pi/2), \qquad (5)$$

$$K_n'(z) = -\left(\frac{\pi}{2z}\right)^{1/2} e^{-z}\left[1 + \frac{4n^2-1}{8z} + \frac{(4n^2-1)(4n^2-9)}{2!(8z)^2} + \frac{(4n^2-1)(4n^2-9)(4n^2-25)}{3!(8z)^3} + \dots\right], \quad (|\arg z|<3\pi/2) \qquad (6)$$

and then the dispersion relation can be given in the form independent of mode number n

$$ka = \frac{1}{2}\cdot\frac{\epsilon_{pin} - \epsilon_{pout}}{\epsilon_{pin} + \epsilon_{pout}} \qquad (7)$$

This last equation shows that the modulus of the wove number k can be infinite, and the dispersion relation has an asymptote only when

$$\epsilon_{pin} = -\epsilon_{pout} \qquad (8)$$

If the permittivities of plasmas are complex (presence of dissipative processes) the condition (8) cannot be satisfied, and wavenumber has an upper bound.

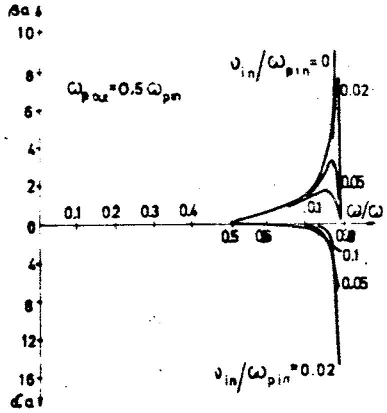

Fig. 1.

Figure 1 compares the normalized propagation characteristics of axially symmetric mode ($n = 0$) for a lossless case ($\nu_{in} = \nu_{out} = 0$), which is obtained by equation (4), with the normalised propagation characteristics obtained by equation (7) for all modes, $\nu_{out} = 0$, $\omega_{pout} = 0.5\,\omega_{pin}$ and various ratios of collision and plasma frequency in the inner plasma. This figure shows, that guided electron plasma waves can propagate ($\beta > 0$) only in the frequency region from the plasma frequency of the outer plasma ω_{pout} up to frequency at which the modulus of the inner plasma permittivity is equal to the modulus of the outer plasma permittivity.

Provided the electron collision frequencies much smaller than plasma frequencies, the phase coefficient is largest when

$$\mathrm{Im}(\epsilon_{pout} + \epsilon_{pin}) = \mathrm{Re}(\epsilon_{pout} + \epsilon_{pin}) \qquad (9)$$

and the respective value is

$$\beta_m = 2^{-5/2}a^{-1}(\omega_{pin}^2-\omega_{pout}^2)\sqrt{\omega_{pin}^2+\omega_{pout}^2}\,(\nu_{in}\omega_{pin}^2+\nu_{out}\omega_{pout}^2)^{-1} \qquad (10)$$

This value is finite although the group velocity is infinite in this point. The attenuation coefficient α in this point is equal to value β_m which is given by equation (10).

When the modulus of inner plasma permittivity is equal to the modulus of outer plasma permittivity, the phase coefficient β is equal to zero and the attenuation coefficient reach the largest value, which is given by

$$\alpha_m = 2\beta_m = 2^{-3/2}a^{-1}(\omega_{pin}^2-\omega_{pout}^2)\sqrt{\omega_{pin}^2+\omega_{pout}^2}\,(\nu_{in}\omega_{pin}^2+\nu_{out}\omega_{pout}^2)^{-1} \qquad (11)$$

It is interesting to note that the largest value of the attenuation coefficient (α_m) is inversely proportional to the electron collision frequencies.

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INFLUENCE OF ELECTRON COLLISIONS ON THE PROPAGATION OF GUIDED ELECTRON PLASMA WAVES ALONG THE CYLINDRICAL INTERFACE BETWEEN TWO PLASMAS

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It is shown theoretically that the presence of electron collision in plasmas limits the phase constant of guided electron plasma waves propagating along the cylindrical interface between two plasmas.

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ON THE STARK BROADENING OF HEAVY, NON-HYDROGENIC NEUTRAL ATOM LINES IN PLASMAS

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Stark broadening of spectral lines is used as an important plasma diagnostic technique for a number of years. First comprehensive calculations of Stark broadening parameters of prominent non-hydrogenic atom lines of light elements were published in 1962. Since than numerous experiments were performed in order to check these theoretical data. Comparison with experiment (see Griem 1974 and Konjević and Roberts 1976) showed for lighter elements (helium through calcium) and cesium an average agreement within ±20% while for heavier elements there was no theoretical data to compare.

In this paper we report results of semiclassical calculations of Stark broadening parameters for a number of heavy neutral atom lines and the results of comparison with the experiment.

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