

## **Influence of Collisional Processes on the Astrophysical Plasma Spectra – Research at the Belgrade Astronomical Observatory**

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**Abstract.** Activities on the project “Influence of collisional processes on the astrophysical plasma spectra”, supported by the Ministry of Science and Environment protection from 1st January 2002 up to 31st December 2005 are reviewed, including other scientific results of the project participants.

### **1 Research on the Influence of Collisional Processes on the Astrophysical Plasma Spectra on Belgrade Astronomical Observatory**

From 1. January 2002, activities on investigation of the influence of collisional processes on the astrophysical plasma spectra are organized at Belgrade astronomical observatory within the frame of the project with the same name, supported by the Ministry of Science and Environment protection of Serbia.

Investigations made within the frame of the Project concern plasma in astrophysics, laboratory and technology and the corresponding modelling, determination and research of atomic and molecular processes, optical properties and spectra, with a particular accent on the role of collisional processes. The particular attention has been paid to the investigation of spectral line profiles, broadened by collisions with charged particles (Stark effect). Such investigations are of interest for the diagnostics and modelling of stellar plasma, plasma in laboratory and technological plasma. Semiclassical perturbation and Modified semiempirical methods were used, tested and investigated. Stark broadening parameters, line width and shift, were determined for a large number of spectral lines of Ag I, Ar I, Cd I, Ga I, Ge I, Kr I, Ne I, F II, In II, Ne II, Ti II, Be III, Cd III, Co III, Cu III, F III, S III, Si III, Zn III, and Si IV. The results obtained were applied for the investigation of the influence of Stark broadening of spectral lines in stellar atmospheres. Particularly was investigated the role of Stark broadening at chemically peculiar A type (Ap) stars, as for example Stark broadening of the neutral chromium spectral lines in the spectrum of chromium rich star Beta CrB and of neutral silicon spectral lines in the roAp 10 Aql star atmosphere. Ab initio calculations of Stark broadening parameters of Ne V spectral lines, observed by cosmical Rendgen telescope “Chandra” was made by using the SUPERSTRUCTURE code and the semiclassical perturbation Stark broadening theory. The Modified semiempirical theory was adapted to use more accurate collision strengths from literature, instead of semiempirical Gaunt factor. The adapted theory was applied and tested on ionized oxygen spectral lines.

The large optical flare was observed on AT Microscopii, and modelled using PHOENIX code for the modelling of stellar atmospheres.

The influence of the (n-n') mixing in Rydberg H\*(n) atom – H(1s) collisions in Solar atmosphere was investigated, as well as the influence of symmetrical chemi-ionization and chemi-recombination processes in low temperature atmospheric layers of helium rich DB white dwarfs. Moreover, the influence of these processes on hydrogen Rydberg energy level populations in atmospheres of M type red dwarfs, was investigated with PHOENIX code.

Transition probabilities for Kr II, Ne II, Kr III were also investigated. The influence of Stark broadening of Cd II spectral laser lines, on the hollow cathode discharge laser working mode was considered. The influence of the radiation pressure on micron-size individual dust grains was experimentally investigated, as well as rotation and alignment of the analogs of interstellar dust grains. By modelling with PHOENIX, lithium in GJ 117 atmosphere was considered.

One of the objectives of the Project is development of database BELDATA.

Participants of the Project published 43 papers in leading international journals, from which 29 are part of the Project and 14 are connected with other research fields. Journals where articles were published (with the number of published papers in the brackets) are: Astronomy and Astrophysics (24), Astrophysical Journal (5), Astronomische Nachrichten (3), Physica Scripta (2), Astrophysical Journal Supplement Series (1), Physical Review E (1), Atomic Data and Nuclear Data Tables (1), European Physical Journal D (1), Journal of Geophysical Research: Space Physics (1), Journal of Physics B: Atomic, Molecular and Optical Physics (1), Applied Physics B: Lasers and Optics (1), Revista Mexicana de Astronomia y Astrofisica (1) and Monthly Notices of the Royal Astronomical Society (1). In international refereed journals [Memorie della Societa Astronomica Italiana Supplementi (17), Astronomical and Astrophysical Transaction (4), Zhurnal Prikladnoj Spektroskopii (2) and its english translation Journal of Applied Spectroscopy (2), High Temperature Material Processes (2), Journal of Aerosol Science (1), European Journal of Science and Theology (1)] were published 29 bibliographic items and 19 are part of the Project. We give also other results, where the first number is the total number, the second is the number of bibliographic items entering in the Project and the last one the number of results not connected with the Project. They are: Invited lectures on international conferences published in books of international publishers (4-2-2), monographs published in Serbia (4-2-2), review articles in publications of national publishers (5-1-4), articles in books of international publishers (14-8-6), articles in national journals (11-1-10), published invited lectures in international conferences (7-5-2), contributions in proceedings of international conferences (24-15-9), published invited lectures at national conferences (5-3-2), contributions in proceedings of national conferences (25-12-13), abstracts of invited lectures on international conferences (9-5-4), abstracts of presentations on international conferences (48-37-11), abstracts of invited lectures on national conferences (8-4-4), abstracts of presentations on national conferences (25-14-11), announcements in astronomical circulars (5-0-5), PhD Theses (2-0-2) and MSc These (1-1-0). In total, Project participants published 261 bibliographic items, and 156 are related to the Project while 107 are not.

Besides described scientific activities and results, important goals of the Project are scientific formation and education of young participants (one defended MSc Thesis and

### *Influence of Collisional Processes on the Astrophysical Plasma Spectra*

work on two PhD Theses), and development of international scientific collaboration with Bulgaria, Russia, France, Greece, Ukraine, Tunisia, Spain, Hungary, United Kingdom, Germany, Holland and USA.

I would mention that significant attention was paid to development of collaboration with Serbian colleagues as well, so that participants of the Project cooperated creatively and fruitfully with Serbian scientists working in the considered research field: Anatolij A. Mihajlov, Ljubinko Ignjatović, Zoran Djurić, Ljiljana Skuljan, Vladimir Milosavljević, Stevan Djeniže, Aleksandar Srećković and Srdjan Bukvić.

Having in view the significance of scientific conferences for the development of scientific collaboration as well as for the scientific formation and education of young participants and professional discussion of results obtained, particular efforts were made in organization of such activities. Participants of the Project have not only take part in organization of 17 scientific conferences as members of Scientific Committees, but five of them organized directly, giving in such a way their contribution to the development of scientific collaboration. Conferences organized by the participants of the Project are:

1. DEVELOPMENT OF ASTRONOMY AMONG SERBS II, Belgrade 5-7. IV 2002, Chairman of the Scientific Committee and member of the Honorary Committee M. S. Dimitrijević, Chairman of the Local Organizing Committee E. Bon, members P. Jovanović, Z. Simić.
2. IV SERBIAN CONFERENCE ON SPECTRAL LINE SHAPES, Arandjelovac, 10-15. X 2003, Co-Chairman of the Scientific organizing committee M. S. Dimitrijević, L. Č. Popović, Chairman of the Local organizing committee M. S. Dimitrijević, members M. Dačić, E. Bon, Z. Cvetković, P. Jovanović, N. Milovanović, Z. Simić, L. Č. Popović.
3. IV SERBIAN-BULGARIAN ASTRONOMICAL CONFERENCE, Belgrade, 21-24. IV 2004, Co-chairman of the Scientific Committee M. S. Dimitrijević, members L. Č. Popović, M. Dačić, Chairman of the Local Organizing Committee M. S. Dimitrijević, members M. Dačić, E. Bon, Z. Cvetković, P. Jovanović, N. Milovanović, Z. Simić.
4. DEVELOPMENT OF ASTRONOMY AMONG SERBS III, Belgrade 25-28. IV 2004, Co-chairman of the Scientific Organizing Committee M. S. Dimitrijević members L. Č. Popović, M. Dačić, Chairman of the Local Organizing Committee M. S. Dimitrijević, members M. Dačić, E. Bon, Z. Cvetković, P. Jovanović, N. Milovanović, Z. Simić.
5. 5th SERBIAN CONFERENCE ON SPECTRAL LINE SHAPES IN ASTROPHYSICS, Vršac 6–10 June 2005, Co-chairman of the Scientific Organizing Committee M. S. Dimitrijević, L. Č. Popović, member D. Jevremović, Chairman of the Local Organizing Committee M. S. Dimitrijević, members M. Dačić, E. Bon, V. Borka, P. Jovanović, N. Milovanović, Z. Simić.

## **2 Participants**

From 2002 to 2004, 10 researchers were working on this project, and in 2005 seven, all from Belgrade Astronomical Observatory. The coordinator of the project during all period (1<sup>st</sup> January 2002 – 31<sup>st</sup> 2005) was M. S. Dimitrijević, and the participants are:

*M.S. Dimitrijević*

1. Edi Bon (born 1970) 2002-2004, total 6 Research Months (RM)
2. Miodrag Dačić (born 1946) 2002-2005, total 27 RM
3. Milan S. Dimitrijević (born 1947) 2002-2005, total 37 RM
4. Darko Jevremović (born 1968) 2002-2005, total 2 RM
5. Predrag Jovanović (born 1968) 2002-2004, total 6 RM
6. Nenad Milovanović (born 1979) 2002-2005, total 48 RM
7. Luka Č. Popović (born 1964) 2002-2005, total 8 RM
8. Zoran Simić (born 1967) 2002-2005, total 30 RM
9. Dragana Tankosić (born 1968) 2002-2005, total 48 RM
10. Zorica Cvetković (born 1958) 2002-2004, total 15 RM

During four years, ten participants were engaged for 227 research months, i.e. 18.9 years. The average age was around 40 years (or year of birth 1963.5).

### **3 Financing of the Project**

The Ministry of Science and Environment protection of Serbia, accepted the project in accordance with the call for projects announced in 2001, and the detailed financial structure of this project is given in the Table 1.

Decisions on expenses for institution were made by director, while decisions concerning expenses for travels, materials and equipments were made on the project level. They were spent for travelling, international collaboration, small equipments, supplies and material.

### **4 Conclusions**

We hope that review of our activities during the 2002-2005 period would be helpful and inspirative for ideas on the collaboration development with our colleagues. This should also illustrate our small contribution to the common effort of humanity to develop fundamental sciences as a basis for the further development.

### **Appendix**

With an asterisk are denoted papers which are not a part of the considered project.

#### **Papers in the leading international journals**

1. M. S. Dimitrijević, S. Sahal-Bréchet: STARK BROADENING OF In II SPECTRAL LINES, *Physica Scripta* 65, (2002), 83-95.
2. S. Djeniže, V. Milosavljević, M. S. Dimitrijević: STARK SHIFTS AND TRANSITION PROBABILITIES IN THE Ne II SPECTRUM, *Astron. Astrophys.* 382, (2002), 359-367.

*Influence of Collisional Processes on the Astrophysical Plasma Spectra*

Table 1. Financial structure of the project 1195.

2005.	
Salaries for the researchers	2.479.360 CSD
Expenses of the institution	1.363.373 CSD
Expenses for travels, materials, equipment...	124.371 CSD
<b>SUB-TOTAL</b>	<b>3.967.104 CSD</b>
2004.	
Salaries for the researchers	1.867.936 CSD
Expenses of the institution	1.245.251 CSD
Expenses for travels, materials, equipment...	207.285 CSD
<b>SUB-TOTAL</b>	<b>3.320.472 CSD</b>
2003.	
Salaries for the researchers	1.331.835 CSD
Expenses of the institution	1.219.571 CSD
Expenses for travels, materials, equipment...	126.781 CSD
<b>SUB-TOTAL</b>	<b>2.678.187 CSD</b>
2002.	
Salaries for the researchers	1.286.294 CSD
Expenses of the institution	670.140 CSD
Expenses for travels, materials, equipment...	89.397 CSD
<b>SUB-TOTAL</b>	<b>2.045.831 CSD</b>
<b>TOTAL 2002-2005.</b>	<b>12.011.594 CSD</b>
	(~160,000 EUR, 1EUR = 75 CSD)

3. M. S. Dimitrijević, Lj. Skuljan, S. Djeniže: STARK BROADENING OF THE Ar I SPECTRAL LINES 763.51, 738.39 AND 696.54 nm, *Physica Scripta* 66, (2002), 77-81.
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11. M. S. Dimitrijević, M. Dačić, Z. Cvetković, S. Sahal-Bréchet: STARK BROADENING OF MULTICHARGED IONS OF ASTROPHYSICAL INTEREST. XXIII Be III, *Astron. Astrophys.* 400, (2003), 791-793.
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15. A. A. Mihajlov, Lj. M. Ignjatović, M. S. Dimitrijević, Z. Djurić: SYMMETRICAL CHEMI-IONIZATION AND CHEMI-RECOMBINATION PROCESSES IN LOW-TEMPERATURE LAYERS OF HELIUM-RICH DB WHITE DWARF ATMOSPHERES, *Astrophys. J. Suppl. Series* 147, (2003), 369-377.
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*M.S. Dimitrijević*

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