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TWO-COMPONENT MODEL
FOR III ZW 2 BROAD LINE REGION

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Abstract. We have modelled the central emitting broad line region (BLR) of the III Zw2 using the H_α H_β Ly_α and Mg II (2798) broad lines. We proposed that two-component model, consisting of inner Keplerian relativistic disk and an outer emitting structure that surrounds the disk, can explain the shape of III Zw 2 Broad Lines

1. INTRODUCTION

According to Arp (1968) and Zwicky (1971) the active galaxy III Zw 2 (Mrk 1501) appears to be essentially stellar-like, with faint wisps extending towards the northwest. The broad emission lines of this object, suggest that this is a type 1 Seyfert galaxy or a quasar (Arp, 1968; Sargent, 1970; Osterbrock, 1977). Studies of III Zw 2 have been also done by other authors (Osterbrock, 1977; Kaastra and Korte, 1988; Corbin and Borson, 1996; and Crenshaw et al., 1999).

There have been some suggestions of the presence of a disk in III Zw 2 (Kaastra and Korte, 1988; Corbin and Borson, 1996; Shimura and Takahara, 1995; Rokaki and Boison, 1999.)

Here we studied the spectral line shapes of H_α, H_β, Ly_α and Mg II (2798) of III Zw 2 in order to identify features in emission lines that might be associated with the emission from a rotating disk.

2. SELECTION OF DATA AND METHOD OF ANALYSIS

We used spectra taken from three sources: (i) 35 spectra of Hβ line (wavelength interval 4750-5900 Å) observed at the Crimean Astrophysical Observatory (CrAO) by K. K.Chuvaev with the 2.6 m Shain telescope, during the period of 1972-1990 (HJD 2441361 till 2448153); (ii) spectra taken with HST (Faint Object Spectrograph - FOS) in 1992 which include the Lyα and MgIIλ2798 lines, and (iii) 3 spectra taken in 1998 with the Isaac Newton Telescope (INT) at La Palma Observatory including the Hα and Hβ lines.

Standard reduction procedures including flat-fielding, wavelength calibration, spectral response, and sky subtraction were performed with the help of the IRAF software package (see Popovic et al., 2003).

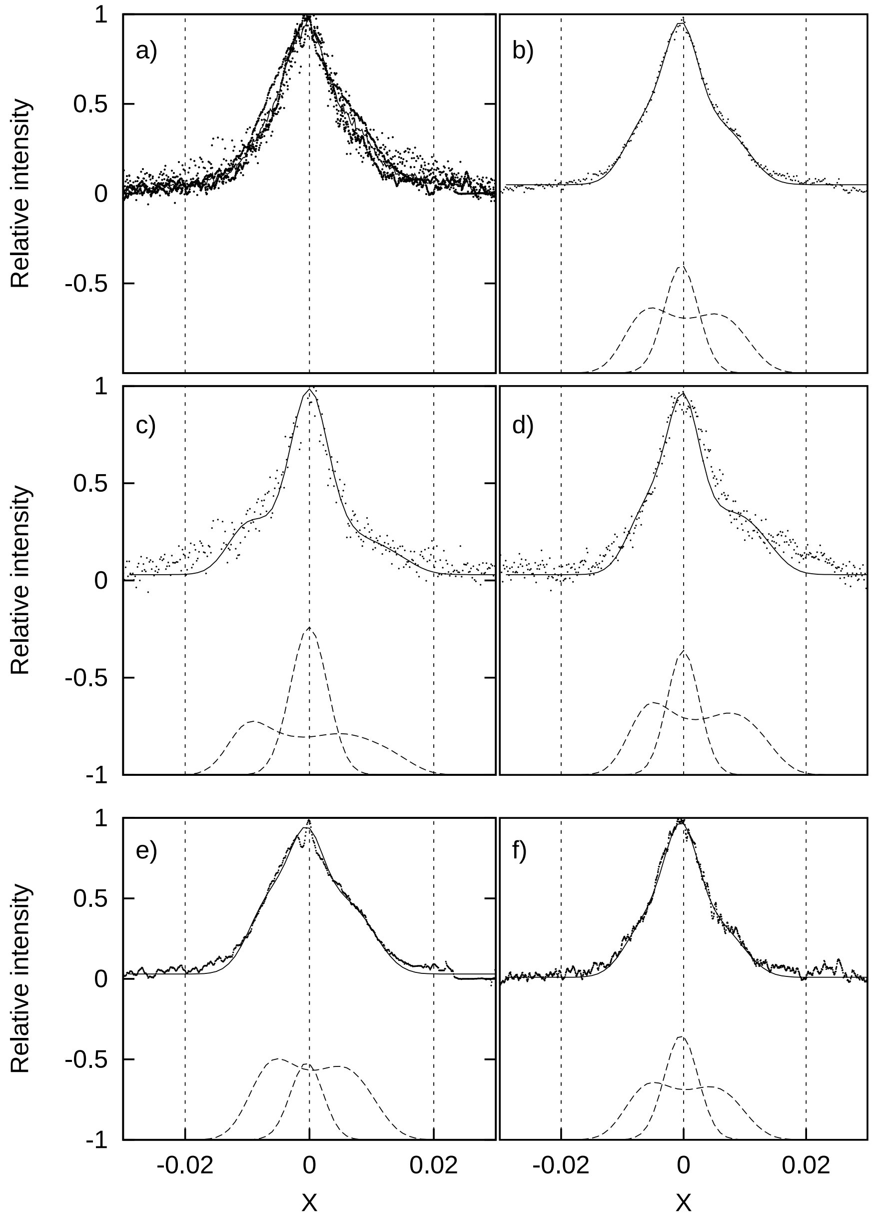

Fig. 1: Observed lines of III Zw 2 (dots), fitted with the disk model (double-peaked) and one Gaussian (dashed lines at the bottom); a) the comparison of all line profiles (dashed lines) with an averaged one (solid line); b) fits of the averaged line profile. Panels c,d,e,f represent fit of Lyα, Mg II, Hβ and Hα lines, respectively. The value of X is $(\lambda - \lambda_0)/\lambda_0$.

The red-shift of III Zw 2 was taken to be z=0.0898 (Véron-Cetty and Véron, 2000).

3. RESULTS

We fitted these line profiles with a disk model (Chen and Halpern, 1989, Chen et al., 1989) plus one Gaussian component which represents the region which surrounds the disk. For the disk we use the Keplerian relativistic model of Chen and Halpern (1989). The emissivity of the disk as a function of radius, R, is given as $\epsilon = \epsilon_0 R^{-p}$, where we suppose that the power index is $p = 3$, considering that the illumination is due to an extended source from the center of the disk and that the radiation is isotropic, Also, we express the disk dimension in gravitational radii ($R_g = GM/c^2$, where G is the gravitational constant, M is the mass of the central black hole, and c is the velocity of light). The local broadening (σ) and shift ($z_{\rm Disk}$) within the disk have been taken into account (Chen and Halpern, 1989).

All spectra were first 'cleaned' before this analysis by subtracting the components obtained from the Gaussian analysis that were found to originate from the other regions (narrow lines) or other elements (Fe II, OIII, N V). Also, the absorption lines were subtracted. After this, the features associated with the disk were visible not only in the asymmetrical wings of Mg II but also in the red and blue shoulders of the Lyα and Hα as well as in the triangular shape and the red shoulder of Hβ (see Fig. 1). To compare the line profiles we present in Fig. 1a the intensities normalized to the peak ones *vs.* $X = (\lambda - \lambda_0)/\lambda_0$. The considered lines have similar line shapes after this operation.

The results of the fit presented in Fig. 1b-f and Table 1 are the following:

(i)There is a very good consistency among the z and W parameters of the broad components representing the region surrounding the disk.

(ii) Red-shifts for the disk corresponding to Lyα, Hα, Hβ, and MgII are consistent. The average z for these four disk lines appears to be slightly blue-shifted (by about 600 km/s) with respect to the systemic one.

(iii) The inner radius of the Lyα emitting disk is clearly smaller than the others. Hα and Hβ exhibit a very good coincidence of the inner radii but the inner edge of the MgII emission ring seems to be closer to the disk center although this point should be viewed with caution.

4. CONCLUSIONS

The main conclusion which can be drawn from the present analysis of the Hα, Hβ, Lyα and MgIIλ2798 is that these lines mainly exhibit two Gaussian components that were red-shifted and blue-shifted to the central one. It has led us to the conclusion that this emission could be explained with a two-component model of emitting disk plus a surrounding region (see Popović et al., 2003). The disk emission (see van Groningen, 1983; Kaastra and Korte, 1988; Chen and Halpern, 1989; Rokaki and Boisson, 1999) can describe the line wings, and the core of the lines can be represented by emission of a region which surrounds the disk.

After fitting the III Zw2 Lyα, MgII, Hβ, and H$_\alpha$ lines we found that the two-component model can describe the shape of the broad lines, and that emission of a disc is present in these lines. The same two-component model (Keplerian relativistic

Table 1: The parameters of disk: z_{disk} is the shift and σ is the broadening term of Gaussian from disk indicating the random velocity in the disk, R_{inn} are the inner radii, R_{out} are the outer radii. The z_G and W_G represent the parameters of the Gaussian component. $< AV >$ is an averaged profile (see Fig. 1b). F_D/F_G represents the ratio of the relative disk and Gaussian fluxes.

Line	z_{disk}	σ (km/s)	R_{inn} (R_g)	R_{out} (R_g)	z_G	W_G (km/s)	F_D/F_G
Lyα	-800	850	200	900	-20	1280	1.11
Mg IIλ2789	-350	920	300	1000	-30	1100	1.86
Hβ	-600	920	400	1300	-130	1100	3.14
Hα	-600	850	450	1300	-120	1170	1.52
$< AV >$	-600	890	400	1200	-120	1170	1.72

disk + a surrounding emission region) can consistently fit the 4 BELs considered here (Lyα, MgII, Hβ, and Hα).

From the fitted disk parameters and the mass of the central object (Vestergaard, 2002) we can estimate that the Lyα disk has inner and outer radii of around 0.0018 and 0.01 pc, respectively. However, the inner radius is greater for the Mg II ($\sim$ 0.0027 pc) and for the Hα and Hβ lines ($\sim$ 0.0038 pc). This indicates a radial stratification in the disk. The relatively broad component present in the blue wings of the narrow [OIII] lines is another indication of stratification (see Popović et al., 2003) and perhaps could indicate a connection between the outer BLR and the NLR.

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