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ACTIVE GALACTIC NUCLEI WITH DOUBLE PEAKED LINES: Akn 120, 3C390.3 AND III Zw2

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Abstract. We have analyzed the double peaked lines emitted from three Active Galactic Nuclei: Akn 120, 3C390.3 and III Zw2. Our analysis indicates that different effects can be responsible for forming the double peaks in hydrogen lines of these objects.

1. INTRODUCTION

The double peaked emission lines are observed in several Active Galactic Nuclei (AGNs). The shapes of the double peaked spectral lines have been explained by different models (see e.g. Zheng *et al.* 1991, Veilleux & Zheng 1991, Chakrabarti & Wiita 1994, Gaskell 1996, Eracleos *et al.* 1995, 1997, Livio & Chun 1997, Popović *et al.* 1998). Mainly a model with an accretion disk surrounding a black hole and two streams was proposed in explanation of double peaked lines, but it was shown by Livio and Xu (1997) that the double peaked lines in spectra of 3C390.3 cannot be produced by emitting gas in streams. Double peaked lines may indicate existence of a close binary nucleus system, i.e. existence of a binary black hole in the central part of an AGN. Such a model has been considered by Popović *et al.* (1998), and as a result of modeling it was shown that the shapes of double peaked lines can be explained by the model in which the radiation of a close binary broad line region is taken into account.

Here we discuss the shapes of H_β lines from three AGNs - Akn 120, 3C390.3 and III Zw2. In order to investigate the nature of formation of double peaked lines in these objects the H_β complex line shapes have been decomposed in several Gaussian components.

2. THE METHOD OF ANALYSIS AND SHAPE OF H_β LINES

We have analysed the $H\beta$ lines observed at Crimean Astrophysical Observatory by K. K. Chuvaev from 1971 till 1991 (see Popović 1996).

The H_β line shapes and their fits are presented in Figs. 1 - 3. As we can see from the figures, the H_β of Akn 120 and 3C390.3 show clearly two peaks, whereas in H_β line shape of III Zw2 it is not the case. All of the shapes of H_β of considered galaxies are complex. Spectral lines as well as continuum of Akn 120 and 3C390.3 very strongly vary (see e.g. Grandi *et al.* 1999, Peterson *et al.* 1998), the radiation of III Zw2 has no strong variations.

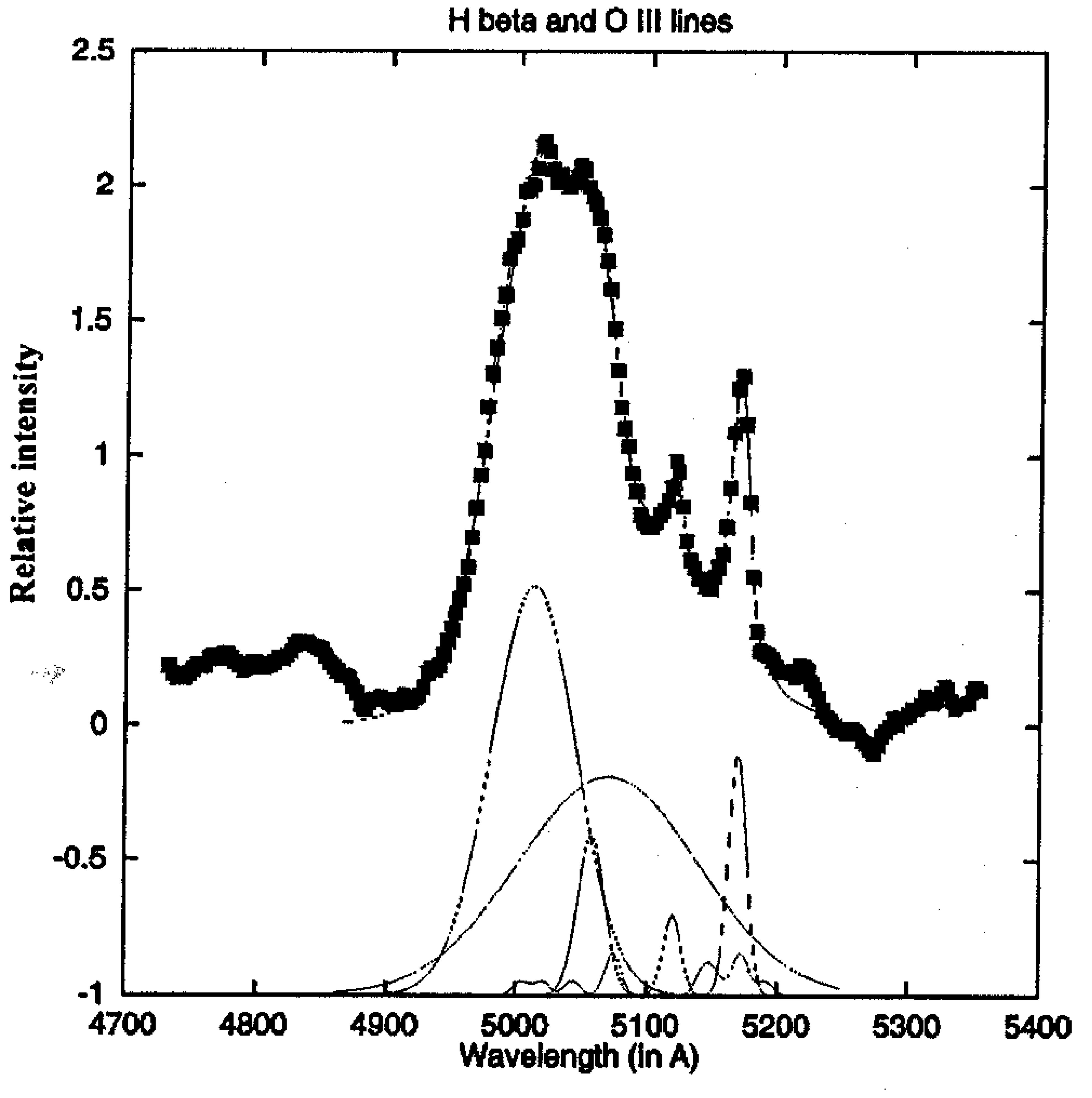

Fig. 1. The shape and the best fit of Akn 120 H_β line.

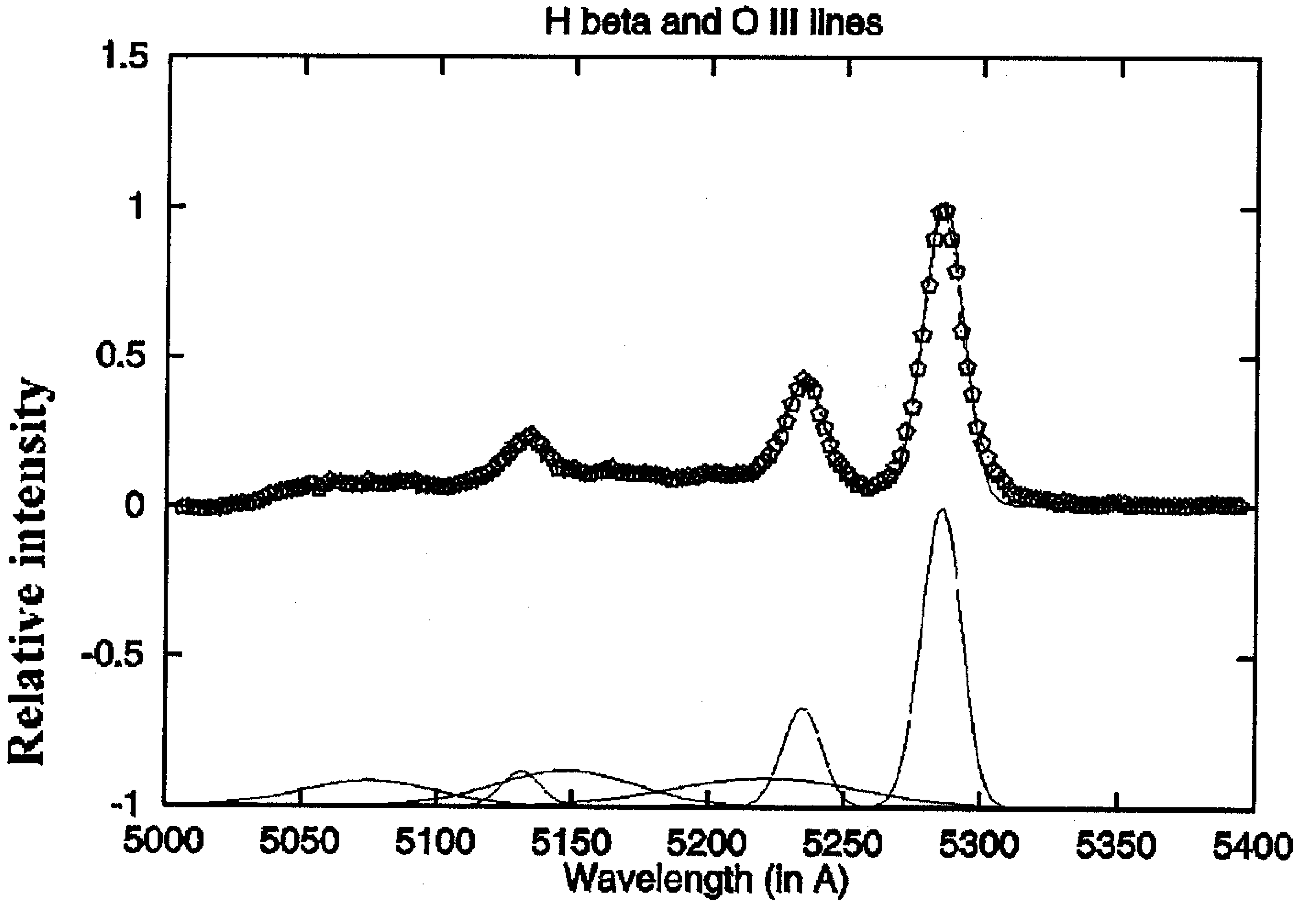

Fig. 2. The shape and the best fit of 3C390.3 H_β line.

First, we have decomposed the lines in several Gaussian components. In order to decrease the number of free parameters, some relations among the fitting Gaussians have been established a priori (see Popović and Mediavilla 1997, Popović *et al.* 1999). The fitted and the decomposed profiles are presented in Figs. 1 – 3. Then the individual spectra were grouped according to time-intervals given by the observational sequences and averaged. Here some variations in time of the line profiles were noticed in spectra of Akn120 and 3C390.3. Final profiles in Figs.1-3 are the non-weighted means of the mentioned groups.

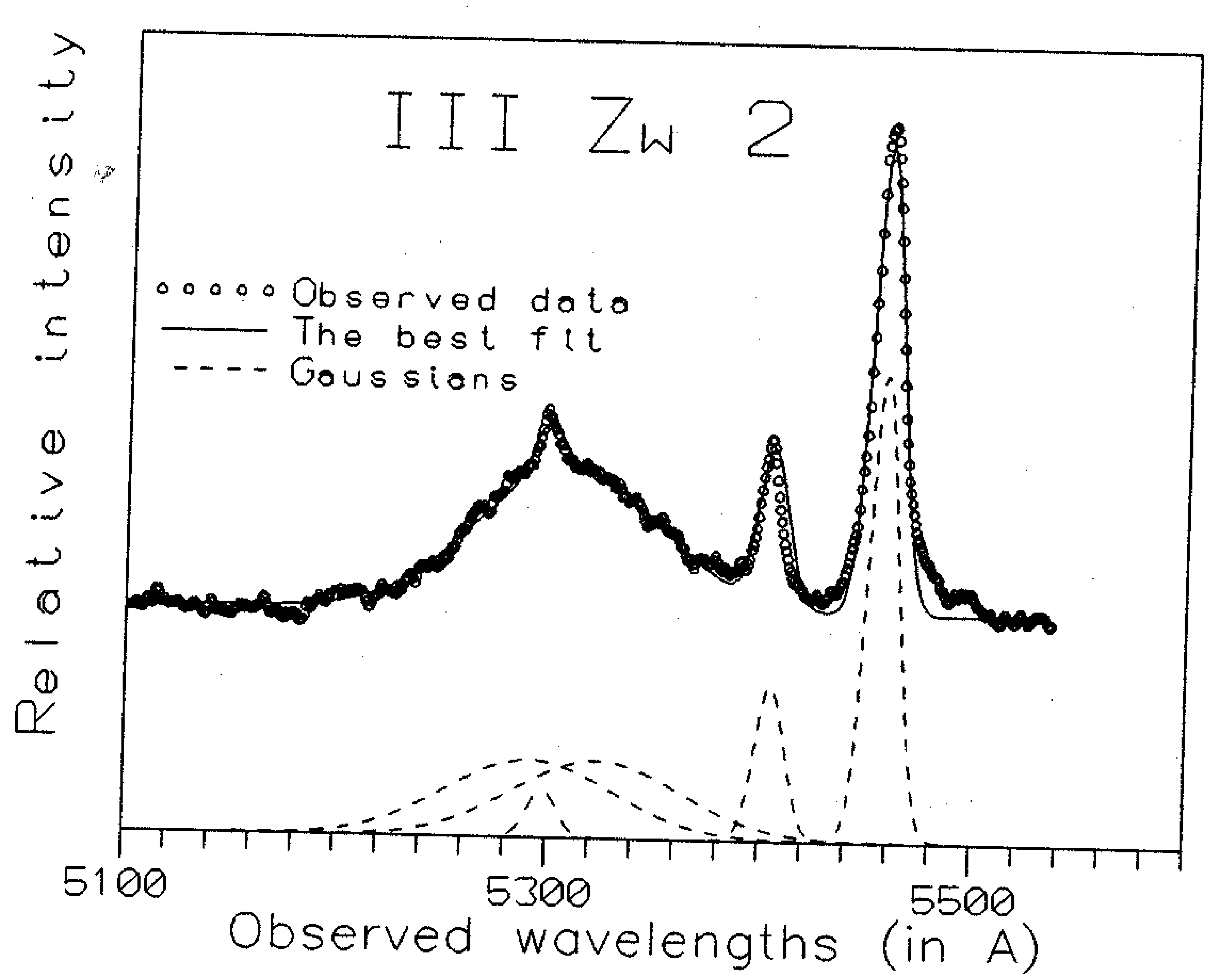

Fig. 3. The shape and the best fit of III Zw2 H_β line.

3. RESULTS AND DISCUSSION

We have analysed the shapes of H_β lines. In the case of Akn 120, the H_β line can be decomposed into four Gaussian components, whereby three of them are broad ones, Fig.1. The broadest components has $w \approx 6000$ km/s, whereas other two broad componet have about 3000 km/s (component shifted toward blue) and $w \approx$1000 km/s (component shifted toward red). The shape of Akn 120 indicates that we have one very broad line-emitting region and two regions of emitting gas whereby the sistematic emitting gas motions are present. It seems that we have one region with high random velocity of emitters ($\approx$ 3000 km/s) which has approaching line-of-sigth velocities, and another one with smaller random velocity of emitters (about 1000 km/s) which has receding line-of-sight velocities. Such shape may be caused by two streams in Broad Line Region of this galaxy, or, alternatively, by existence of close binary nucleus in central part of this galaxy.

Besides the three Gaussians closely connected with H_β a wide multipeaked structure (the shelf) can be noticed at the bottom. Following Korista (1992) we compose it from nine Fe II lines (multiplets 25, 36 and 42). These lines keep their mutual relative strength relations, but as a whole the shelf contribution - instead of being taken as proportional to Fe II 4570 complex - is defined by our procedure of fitting H_β, O III 4959 and O III 5007 profiles.

The shape of 3C390.3 Hβ line is very complex (e. g. Veilleux and Zheng, 1991). In our case, the Hβ line can be decomposed into three Gaussian components (Fig. 2). Two broad components have practicaly the same width, about 2250 km/s which may indicate the existence of two Broad Line Regions (BLRs). Unlike Akn120, here a very broad line that can predict the existence of one BLR and two streams of emitting gas is not present. Hence, in the case of 3C390.3 we prefer a model with two BLRs.

Gaskell (1996) proposed that the complex shape and time-variation of 3C390.3 H_β line can be explained by a model with a binary black hole. Such a model has been rejected by Eracleous *et al.* (1997). In spite of both views, our analysis indicates that two BLRs should be present in the central part of 3C390.3. Also, a shelf is present in red wing of H_β (Fig. 2).

Although the shape of III Zw2 H_β line does not have two peaks (see Fig. 3), the analyses show that broad componetn of H_β is composed from two identical Gaussian components ($w \approx 3000$ km/s). It may indicate that an emitting disk is present here. It is in agreement with the observation of continuum distribution (Kaastra & de Korte 1988), in which it was observed that energy density increases in the optical part of the spectrum. Such trend can be explained as radiation of a blackbody disk.

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