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H_β LINE PROFILE VARIATION AND THE STRUCTURE OF THE Akn 120 EMITTING REGION

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Abstract. To investigate the structure of the Akn 120 emitting region we have analysed 97 spectral line profiles of H_β line using a Gaussian-decomposition approach. The decomposed shape of the Akn 120 lines indicates three separated broad line emitting regions in all periods considered, where in two of them the systematic motions of emitting gas are present. It seems that one of the two regions has a high random velocity of emitters ($< 2500 km/s$) and approaching line-of-sight velocities and the other has a smaller random velocity of emitters ($< 1000 km/s$) and receding line-of-sight velocities. The H_β line in all groups and in averaged spectrum was fitted with three broad and one narrow Gaussians through the entire period considered (1977-1990). The central broad as well as blue component of H_β and a shelf (Fe II template) cause the H_β line shape variation. The temporal changes of the shifts, widths and areas of the three broad components (blue, central and the red one) are also shown. Gaussian decomposition of H_β spectral line profiles is compared to the same kind of decomposition of H_α, Ly_α, [CIII 1909] and [MgII 2798] lines. RMS analysis in all groups and in averaged spectrum shows the highest scattering of the profiles is within H_β core. This is taken as real change in the H_β flux and profile shape over time. It seems that the core of the H_β line in Akn 120 originates in the two regions (double cones) and the wings arise from the disk and a central, highly turbulent region which may be disk-like.

0. 1. THE OBSERVATION AND THE REDUCTION OF THE SPECTRA

H_β and H_α spectra of active galactic nucleus Akn 120 were obtained by K. K. Chuvaev with 2.6 m telescope Shain at Crimean Astrophysical Observatory (CrAO) in the period 1977-1990. Thereafter 97 H_β negatives were scanned on two-coordinate mycrophotometer (Stanić et al. 2000). Further treatment of the spectrograms was carried out at CrAO to obtain intensity (I(pix)) from the photographic density of spectrogram (D(pix)). SPE program (Sergeev 1993) was used for the wavelength calibration of spectra, the substraction of underlined continuum and the normalization to the [OIII 5007] emission line flux.

Each spectrum has been normalized to the [OIII 5007] total emission line flux and tuned in the scale of RELATIVE INTENSITY. As broad lines originate from the vicinity of the black hole, less than 1pc from the center of nucleus their variation causes line shape variation of H_β. At the other hand, according to generally accepted model of AGN, narrow (or forbidden lines), like [OIII 5007], arise from the outer regions (a few kpc from the center of the nucleus) and we might say that such lines are pretty stable in the considered time period. That is why we took [OIII 5007] total

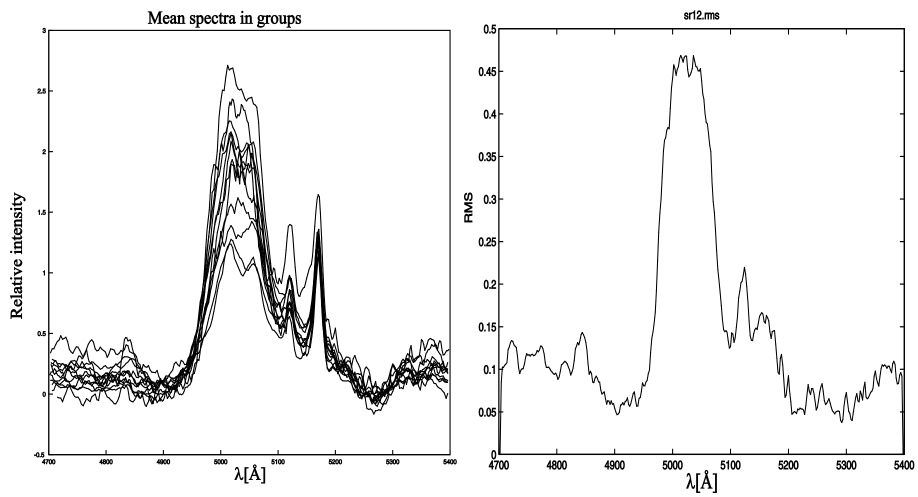

Figure 1: The mean spectra in groups (on the left) and their RMS profile (on the right) for H_β line.

flux as a unit. Each spectrum is cut off in wavelength range 4700 Å - 5400 Å, where the structure of H_β line is prominent enough to be discussed in detail.

0. 2. THE LINE PROFILE VARIATION AND THE RESULTS OF THE GAUSSIAN ANALYSIS

According to observational gaps spectra were divided into 12 groups. The mean spectrum from all 97 spectra as well as inside groups is calculated and in all of them H_β line (4900 Å – 5100 Å) has clearly shown (Fig. 1) double peaked shape (Stanić et al. 2000). Forbidden (narrow) lines [OIII 4959] and [OIII 5007] lie in the right wing of the H_β line. It was also noticed that the left shoulder (so called "blue peak") of the line is stronger than the red one. The Root Mean Square (RMS) analysis has shown the stronger variations in the core than of the wings of H_β line in all analyzed groups and in the mean spectra as well.

After the Gaussian decomposition (Popović et al. 2001) of the H_β line we can conclude that the complex structure of the H_β line (Fig. 2) stays mainly the same in all analyzed groups: there are three broad components where z and $FWHM$ have the following values:

$Z_{blue} = 0.0310$; $FWHM_{blue} = 2500km/s$;
$z_{red} = 0.0405$; $FWHM_{red} = 1000km/s$;
$z_{central} = 0.0382$; $FWHM_{central} = 6000km/s$.

And there is one narrow H_β component with following values:
$z_{narrow} = 0.03248$; $FWHM_{narrow} = 450km/s$,

which are the same in the case of [OIII 5007] and [OIII 4959] lines.

Shape and amplitude variability of the line core is caused by variability of red shifts, widths and intensities of the three broad H_β Gaussians and Fe II red shelf (that consists of nine Fe II lines, multiplets 25, 36 and 42).

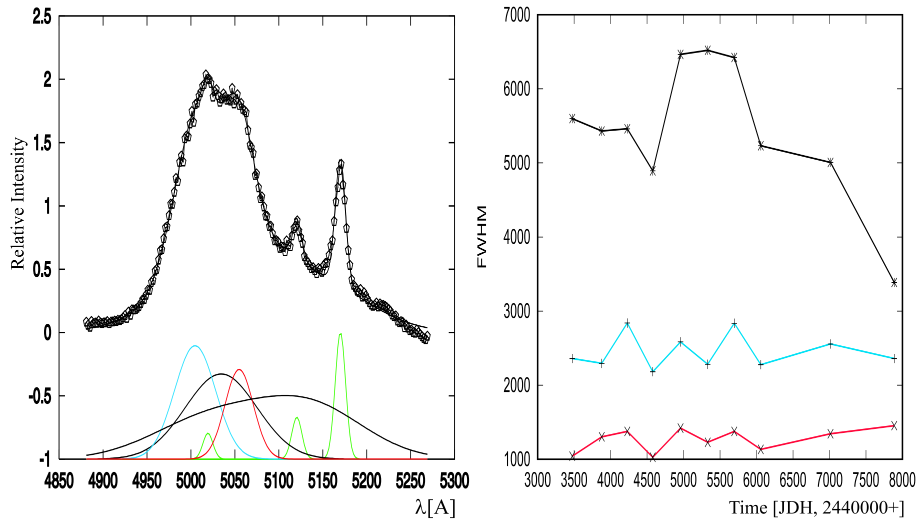

Figure 2: On the left – the result of the Gaussian decomposition of H_β line: the central Gaussian and a shelf (full line), blue and red broad component (dashed line), OIII lines in the right wing (dashed line); and on the right – FWHM variation of three broad components in time: central Gaussian (* – full line), blue Gaussian (+ – dashed line) and red Gaussian (x – dashed line).

For the changes of Gaussian widths (Fig. 2), we can be pretty sure that they have shown the existence of the three SEPARATED broad line emitting regions with apparently different random velocities of emitters. The central Gaussian is the broadest one and its flux variability is greater than in blue and red components during the considered period in time. The reason of the behavior mentioned above we could find in the proposed model for the Akn 120 emitting region.

0. 3. THE MODEL OF THE Akn 120 EMITTING REGION

Emission lines from the central region could be modelled with an extremely turbulent disk-like region and two regions located in axial streams, where one of them is partly obscured by the accretion disk.

Blue and red Gaussians could be interpreted as originating from somewhere outside the accretion disk probably from a biconical BLR (Broad Line Region): BLR1 and BLR2 that fit the core of the H_β line very well. The broadest Gaussian might represent the energy irradiated by turbulent accretion disk or disk-like region. However, in the model (Fig. 3), the wings of H_β line could be fitted by a disk model (Popović et al. 2001).

The biconical model of Akn 120 has to be tested in detail in the future work, for different opening and projection angles of the cone. Connection between UV, optical line shapes and X ray emission of the Akn 120 might also be one of the further tasks.

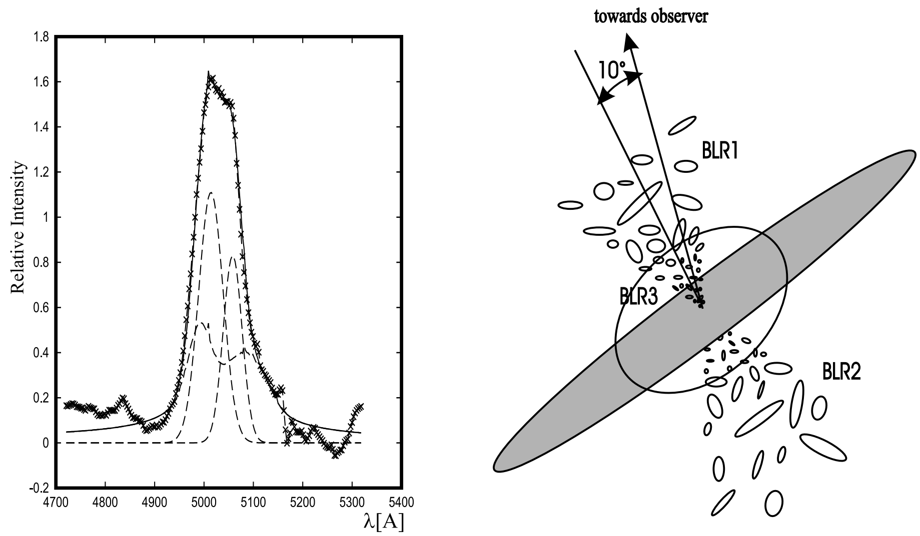

Figure 3: On the left – the observed H_β line (x – full line) fitted with by a model "disk+two broad Gaussians" (dashed lines) and on the right – the scheme for the proposed model.

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References

Osterbrock, D.E.: 1989, *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*, Mill Valley, California.

Popović, L.Č., Stanić, N., Kubičela, A., Bon, E.: 2001, *Astron. Astrophys.*, **367**, 780.

Sergeev, S.G., Heisberger, F.: 1993, *A Users Manual for SPE.*

Stanić, N., Popović, L.Č., Kubičela, A., Bon, E.: 2000, *Serb. Astron. J.*, **162**, 7.

Stanić, N.: 2002, *Msc Thesis: H_β line profile variation and the structure of the Akn 120 emitting region.*