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Rapid Variations in the Broad Hβ Profile of the Radio Galaxy 3C 390.3

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1. Observations and data reduction

We report on rapid variations of the $H\beta$ profile shape in 3C 390.3 over a period of one hour and discuss the implications for the velocity field of the BLR.

Four spectra of the radio galaxy 3C 390.3 were obtained 1991 October 12 at the 6-m telescope using a TV scanner. The mean $FWHM$ of comparison lines is typically ~ 4 Å.The S/N ratio per resolution element in the continuum near the $H\beta$ line for individual spectra is $20 - 35$. No correction for spectral sensitivity has been applied.

To illustrate the rapid variability of the shape of the broad line profiles we used the difference spectrum obtained by subtracting the mean of our last two spectra from the first one. Before subtraction, 1) an average continuum has been subtracted from each spectrum; 2) after this, the spectra have been internally calibrated to a common flux scale, using the total flux over two bands (λ_{obs}: $5030 - 5100$ Å and $5160 - 5210$ Å) in the $H\beta$ wings (cf. Eracleous & Halpern 1993).

2. Results

The difference spectrum is shown in Figure 1 together with the corresponding parent spectra. The difference $H\beta$ profile reveals small, but significant changes in the form of three narrow, positive and negative bumps located at the blue and red sides of the line (marked by arrows). The positions and the S/N ratios of the bumps are -3700, -2300 and $4700\,km/s$ and 6.1, 4.6 and 3.7, respectively. These changes in the shape of $H\beta$ have occurred on a time scale of 1 hour. (The high residuals at the positions of the strong narrow lines in the difference spectrum are a consequence of the TV scanner saturation.)

Similar but long-term profile variation of the $H\beta$ profile of 3C 390.3, resembling our two spectra in Figure 1, has been reported by Osterbrock, Koski and Phillips (1976), Veilleux and Zheng (1991) and Dietrich and Kollatschny (1994). Comparison of our data with these observations provide evidence in favour of the reality of the changes observed by us which occured, however, on a time scale of only one hour.

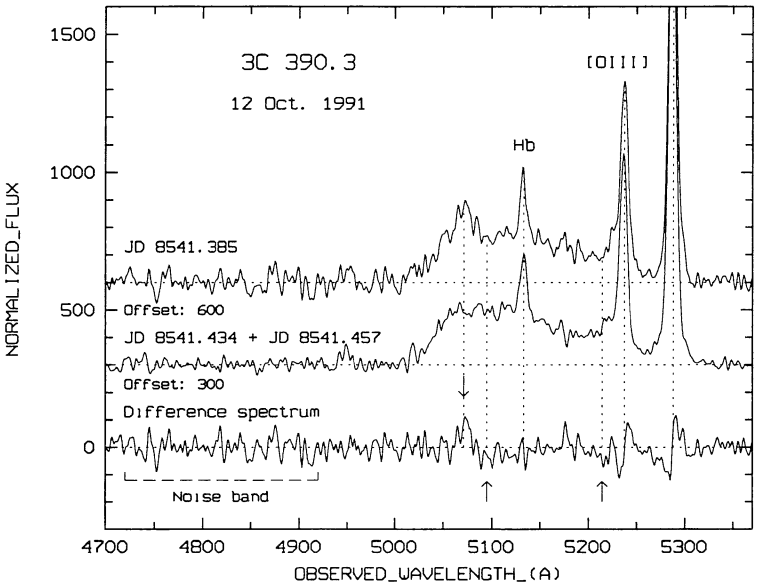

Figure 1. Spectra of 3C 390.3 obtained 1991 October 12 and their difference.

3. Discussion

The variations occur simultaneously at the blue and red sides of the $H\beta$ profile. This may indicate the response of a circularly rotating (accretion) disk to a light pulse from a central source. In this case the two negative features observed in the $H\beta$ difference profile at -2300 and $4700\,km/s$ ($\lambda_{obs} = 5095$ and 5214 Å) are formed in two opposite zones of gas close to the line of nodes. The apparent redward asymmetry in the positions of these bumps (i.e. the redshift of their midpoint) relative to the central line may be due to transverse Doppler and gravitational redshifts in the field of a massive central object (e.g., Netzer 1977). A possible counterpart of the observed blue positive residual (i.e. a red positive one) is not visible in the red wing of the $H\beta$ difference profile. This is possibly related to the superposition of the high residual of the strong $[OIII]$ line with an expected weaker, red positive bump.

The observed "doublet" of a positive and a negative residual appearent on the blue wing can be interpreted as the signature of an intensity peak moving in velocity space. Such small-amplitude profile variations, which take the form of narrow bumps drifting across the line profile, have been predicted by Antokhin and Bochkarev (1983) and Stella (1990).

Thus, the observed $H\beta$ profile variability properties appear to favour models of a relativistic circular disk in the BLR.

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