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The link between the variable optical continuum and the radio emission of the compact jet in a radio-loud Seyfert galaxy 3C390.3

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We obtained observational evidence for the link between variability of the radio emission of the compact jet, optical and X-ray continua emission and ejections of new jet components in the radio galaxy 3C 390.3.

Keywords: Radiation mechanisms: non-thermal; Galaxies: individual: 3C390.3; Active galatic nuclei: optical continuum variations; Radio jets

1 Observations

Ten very long baseline interferometry (VLBI) observations of the 3C 390.3 radio emission at 15 GHz were obtained by Kellermann et al. (2004) from 1992 to 2002.

The spectral and photometric monitorings of 3C 390.3 were carried out at the 6-m and 1-m telescopes of the Special Astrophysical Observatory of the Russian AS (SAO RAS) and 2.1-m telescope of the Guillermo Haro Astrophysical Observatory (GHAO, Cananea, Mexico) and the 2.6 m telescope of the Crimean Astrophysical Observatory (CRAO, Ukraine). High quality spectra (S/N $>$ 50 in the continuum near Hα and Hβ) were obtained using the spectrographs with a long-slit in the spectral range from 4000 to 7500 Å, with a resolution between 5 Å and 15 Å. Spectra were scaled using the [OIII]5007 flux (Shapovalova et al. 2001, Sergeev et al. 2002). UV data were taken from Zheng et al. (1996).

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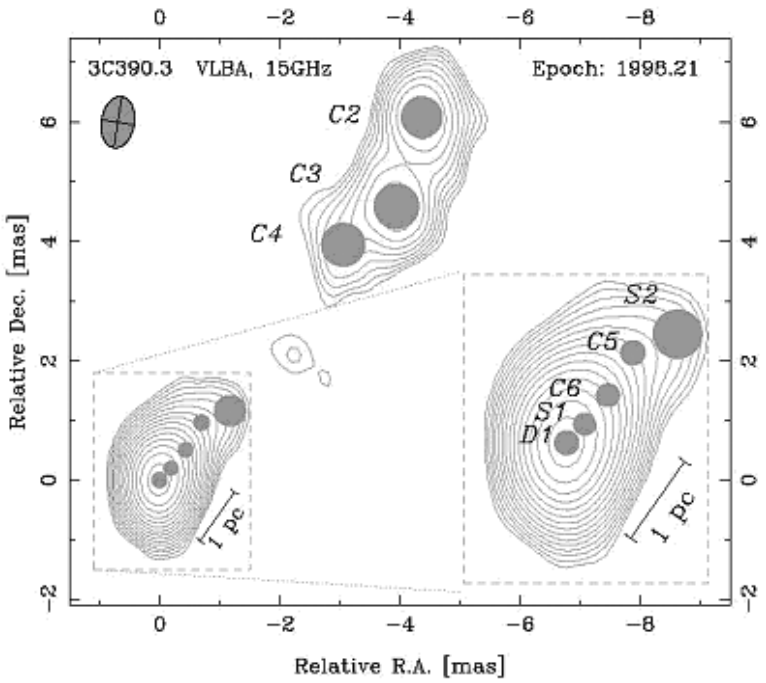


Figure 1 Radio structure of 3C 390.3 observed in 1998.21 with very long baseline interferometry at 15 GHz (2 cm). Innermost fraction of the jet is shown in the inset. The resolving point-spread function (beam) plotted in the upper left corner is 0.87 × 0.55 mas oriented at an angle of 8.0 degrees (clockwise rotation). The peak flux density in the image is 190 mJy/beam and the rms noise is 0.2 mJy/beam (1 Jy = 10^{-26} W m^{-2} Hz^{-1}). The contours are drawn at 1, $\sqrt{2}$, 2... of the lowest contour shown at 0.6 mJy/beam. The structure observed is quantified by a set of two-dimensional, circular Gaussian features (shaded circles) obtained from fitting the visibility amplitudes and phases. Similar fits have been obtained for ten observations from the 15 GHz VLBA survey database [4], for the purpose of cross-identifying and tracing different features in the jet. The labels mark three stationary features (D, $S1$ and $S2$) and a subset of moving components ($C2$–$C6$) identified in the jet.

2 Results

• For ten VLBA images, we identified three stationary features (D, $S1$, and $S2$) and five moving jet-components $C4$–$C8$ (Arshakian et al. 2006). The stationary features $S1$ and $S2$ are separated from D by 0.28 mas and 1.50 mas, respectively (Fig. 1). The proper motions of moving components correspond to apparent speeds of 0.8c to 1.5c.

• In Fig. 2 the light curves of the continuum fluxes (radio, optical, UV) 3C 390.3 during the 1992 to 2002.2 are presented. The variations of the optical continuum are correlated with radio emission from a stationary feature ($S1$) in the jet. The radio fluxes from D and $S1$ features show an apparent anticorrelation during 1996.4–2002.2 time period in the jet.

• For the moving components $C4$–$C7$, the epochs $t(S1)$ of separation from the

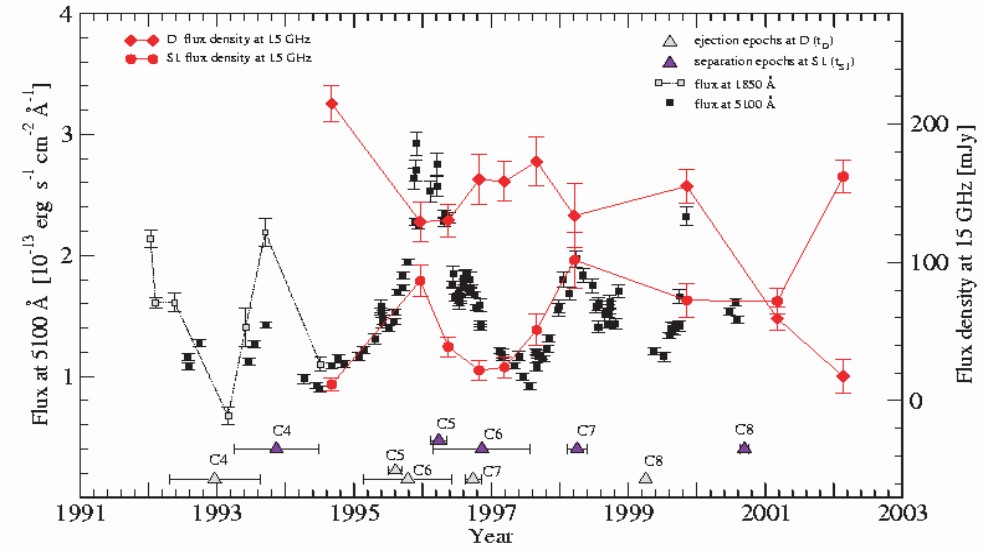


Figure 2 The optical and radio light curves.

stationary feature $S1$ are coincident, within the errors, with the maxima in the optical continuum (Arshakian et al. 2008a, b). All ejection events occur within 0.3 yr after a local maximum is reached in the intensity of the optical continuum. The probability that it happens by chance is very small (<0.0001). This suggests that radio ejection events of the jet components are coupled with the long-term variability of optical continuum (Arshakian et al. 2008a, b).

• The received results imply that the part of variable optical continuum and the broad-line emission associated with it are generated at a large distance from the central engine ($\geq$0.4 pc).

• We support that the broad emission lines having a double-peaked structure originate in two kinematical and physical different regions in 3C 390.3 (Fig. 3):

1) BLR1 – the traditional BLR (Accretion Disk (AD) and the surrounding gas). It is at the distance ∼20–30 light days from the nuclei (Dietrich et al. 1998, Shapovalova et al. 2001).

2) BLR2 – in a subrelativistic outflow surrounding the jet.The localization of the source of optical continuum with the innermost part of the jet near $S1$ implies that the broad line emission originates in the conical region (dimension ∼100 light days) at a distance $\geq$0.4 pc from central engine.

Such a scenario explains two maxima (∼30d and ∼100d) found in the cross-correlation function describing the time-lag of broad line variations relatively to continuum on the base of the results of 3C390.3 optical monitoring in 1996–2000 (Shapovalova et al. 2001).

• During the nucleus maximal brightness periods most of the continuum variable radiation is emitted from the jet and ionizes the surrounding gas, creating a BLR2 that mainly determines the broad line emission. During the brightness minima the jet contribution to the ionizing continuum is decreasing and the main broad line

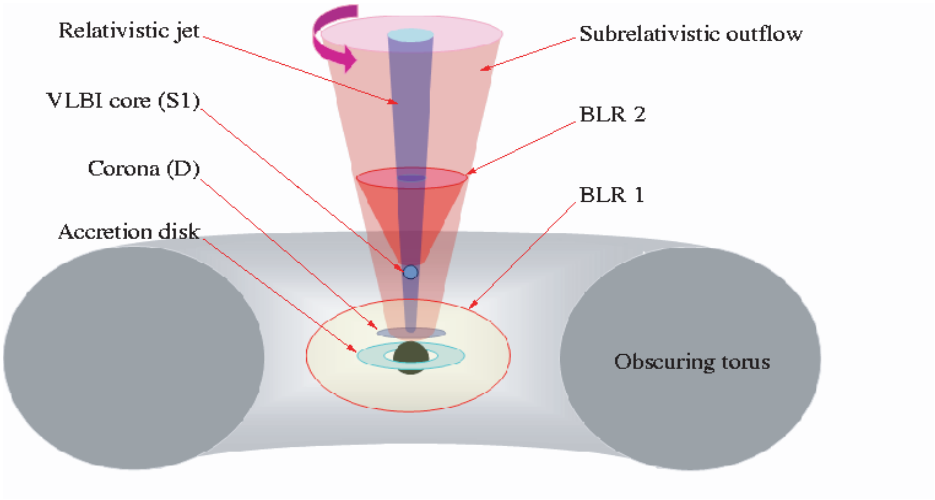


Figure 3 A sketch of the nuclear region in 3C 390.3. The drawing is made not to scale.

emission comes from the "classical" BLR1 (AD) ionized by continuum related with the accretion at BH.

Acknowledgements

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