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Structural Variations in the Quasar 3C 454.3

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Abstract. Imaging of the OVV quasar 3C 454.3 (z=0.859) shows that a new component was ejected from the core at epoch 1981 ± 1, close to the time of a major radio outburst. The component moved along a curved path with a mean apparent velocity of $\sim 17c$ ($H_o = 100 \cdot h$ km s^{-1} Mpc^{-1}). The motion, however, showed variations: from $\sim 11c$ (1984–1985), to $\sim 22c$ (1985–1988.5), then to $\sim 14c$ (1988.5–1991.9).

At epoch $\sim$ 1980, a strong radio outburst began in 3C 454.3. Subsequent global VLBI observations at λ2.8 cm revealed a complex structure, composed of three stationary components and two weak features which appeared to recede from the core along P.A. $-95°$ with velocities of $\sim 9c$ and $\sim 5c$ (Pauliny-Toth et al. 1987, PT87). Global VLBI observations were also made at λ6 cm, at 2–3 yr intervals. Images from these are shown in Fig. 1.

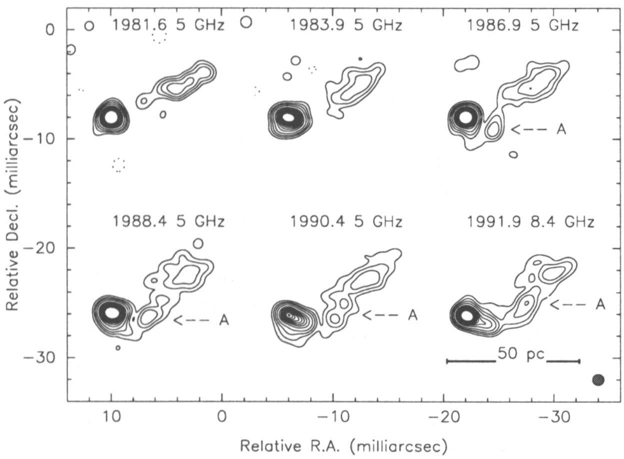

Figure 1. Images of 3C 454.3 derived from global VLBI observations at 5 GHz (first 5 epochs) or 8.4 GHz (last epoch). The restoring beam is a circular gaussian with FWHM 1 mas. Contour levels are $(-1, 1, 2.5, 5, 10, 20...100) \cdot 35$ mJy/beam area, except for the last epoch, where the scaling factor is 24 mJy/beam area.

We associate the feature(s) labeled "A" with the weak, moving components detected at λ2.8 cm. "A" moves away from the core along a curved path. Its distance from the core, measured along this path, is shown in Fig. 2.

The results are as follows:

1) Component A moves along a curved path towards the "mas jet" which was already present at epoch 1981.6.

2) Its velocity along this path changes from $\sim 11c$ (1984–1985), to $\sim 22c$ (1985–1988.5) and then to $\sim 14c$ (1988.5–1991.9). The mean velocity over the whole range of epochs is 0.68 ± 0.02 mas/yr, or $(17.2 \pm 0.6)c$. These velocities are higher than the value of $\sim 5c$, for superluminal sources in general (e.g., Porcas 1987).

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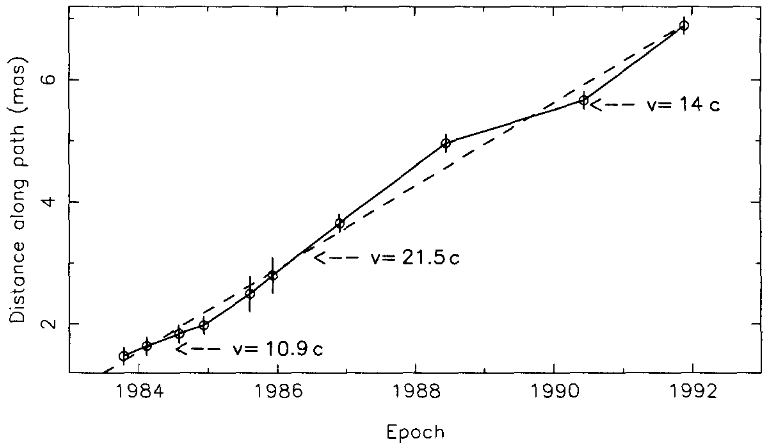

Figure 2. The distance traveled by component A, along its curved path, vs epoch. The velocities indicated are for epochs 1983–1985, 1985–1988.5 and 1988.5–1991.9.

3) The epoch of ejection, using a straight line fit to all the epochs is 1981.7 ± 0.8; for only the first 4 epochs, it is 1980.3 ± 1.0. The latter value corresponds closely to the beginning of the outburst.

4) The distance of the mas jet from the core at 1981.6 is 8.2 mas. The last major outburst in 3C 454.3 before 1981.6 began at $\sim$ 1966.0 (Kellermann & Pauliny-Toth 1981). If this jet originated in that outburst, the velocity would have been $\sim$ 0.53 mas/yr or $\sim 13c$, a value close to those obtained for component A. It thus seems likely that the mas jet originated in the 1966 outburst.

5) The stationary features in the core region reported in PT87 may be simply explained in terms of motion of the jet along a sinusoidal path. A simple, 2-D model is of such a path, with amplitude $\sim$ 0.15 pc, period $\sim$ 40 pc and axis oriented at 3° to the line of sight. The jet has a Lorentz factor $\gamma \sim 20$ and the stationary features represent the points where the jet direction is along the line of sight. This naive model reproduces the observed spacings of the features. At some distance from the core (1–1.5 mas) the path presumably changes and a moving shock (e.g., component A) develops.

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