Detection of Proper Motion of the Sub-Parsec-Scale Jet in 3C 66B

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3C 66B, a giant elliptical galaxy with a redshift (z) of 0.0213, is known as an FR I radio galaxy and it has a prominent core–jet structure that extend to about 100 kpc. High-resolution imaging using very long baseline interferometry (VLBI) at 5 GHz has revealed the presence of a faint counterjet within a distance of 2 mas from the core [1]. The intensity ratio between the jet and counterjet was estimated to be approximately 10, indicating possible acceleration of the jet outflow on a sub-parsec scale. In order to search for motion of the inner jet, we carried out multi-epoch imaging of 3C 66B using VLBA [2].

From images of 3C 66B at 8.4 GHz, we found three knots at 0.7, 1.5, and 2.5 mas (0.3, 0.7, and 1.1 pc) from the core (Fig. 1). Using weighted least-squares fitting, we estimated the proper motion of the inner three knots during 1.3 years to be 0.21±0.03, 0.36±0.04, and 0.63±0.18 mas year^{-1}, which corresponds to $\beta_{\rm app}$= 0.30±0.04, 0.49±0.06, and 0.87±0.24 (Fig. 2).

3C 66B showed that the apparent jet speed increases with a distance from the core within 3 mas (1.3 pc). This result is consistent with the fact that the sub-parsec scale counterjet was found within a distance of 2 mas from the core.

According to the relativistic beaming model, assuming that the jet accelerates with a constant viewing angle of 4.9 degrees [3], the jet speed accelerates from 0.78 c to 0.91 c, corresponding to the bulk Lorentz factor Γ from 1.60 to 2.46. Assuming the other interpretation, that is, a change in the viewing angle with a constant jet velocity of 0.78 c [3], the angle varies from 4.9 to 16.2 degrees. To reveal the kinematics and geometry of the jet in 3C 66B, further monitoring with higher dynamic-range is required over a longer period at 8.4 GHz or higher.

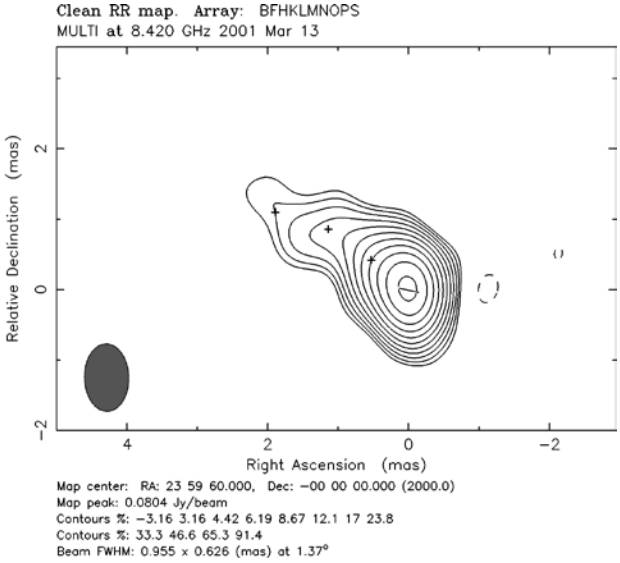

Figure 1: An 8.4 GHz image of 3C 66B observed at 2001.20. Contours are drawn at 3-σ × (1, $\sqrt{2}$, 2, 2$\sqrt{2}$, ...), the 3-σ level in this image is 0.8 mJy beam^{-1}. The synthesized beam is shown at the bottom-left of the image. The cross marks indicate the fitted position of knots using delta functionin. The Gaussian component of the core position is also shown.

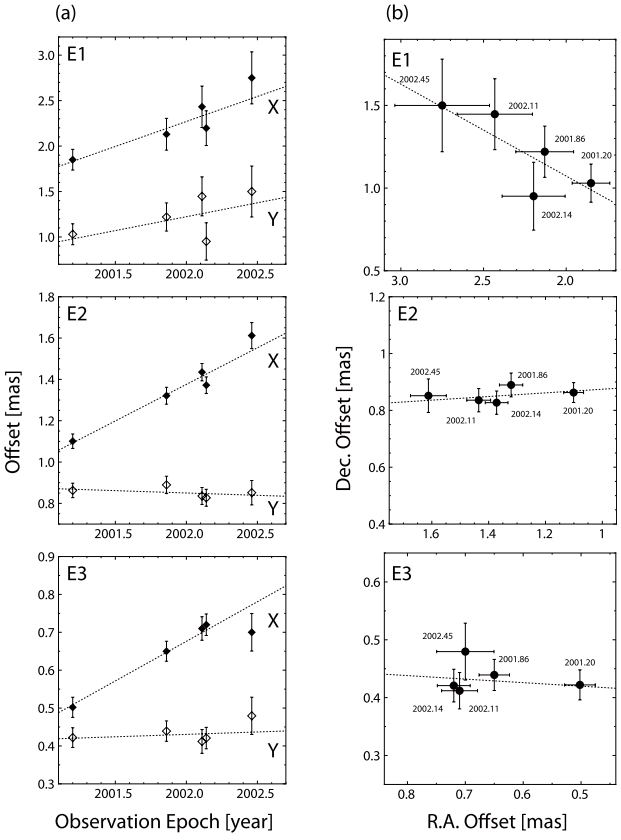

Figure 2: Linear fitting of the relative position shift of the three knots (E1, E2, and E3) at 8.4 GHz. (a) time evolution and (b) spatial distribution. A filled lozenge means the R.A. direction (X), and an open lozenge means the Dec. direction (Y). Dotted lines indicate the best fit.

References

[1] Giovannini, G., et al.: 2001, *ApJ*, **552**, 508.
[2] Sudou, H., Iguchi, S.: 2011, *AJ*, **142**, 49.
[3] Iguchi, S., Okuda, T., Sudou, H.: 2010, *ApJ*, **724**, L166.