Multi-Frequency VSOP and VLBA Polarization Observations of 3C 279 and 3C 345

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Abstract. This contribution presents preliminary results from coordinated polarization sensitive VSOP and VLBA imaging of the blazars 3C 279 and 3C 345 at multiple frequencies.

1. Imaging Relativistic Jets with Space-VLBI

One of the primary goals of orbiting-VLBI, and the VSOP mission in particular, is to image compact radio sources at low frequencies with resolution comparable to that of higher frequency ground-based only observations. This facilitates resolution independent spectral and polarization (rotation measure and field orientation) mapping of relativistic jets in AGN, a capability that is compromised when only ground-based interferometers are used.

To this end, we have obtained polarization-sensitive observations of four bright 3C quasars using the VLBA at 8.4, 15, 22, and 43 GHz, plus coordinated VSOP plus ground station observations at 1.6 and 5 GHz. Here, we present some preliminary results from our first-epoch mapping of 3C 279 (in April 1999) and 3C 345 (from July-Sept. 1998). Chen et al. (2003, this volume) present results on 3C 454.3; work on the fourth source, 3C 273, is in progress.

2. The Parsec-scale Jets in 3C 279 and 3C 345

The quasars 3C 279 (z=0.536) and 3C 345 (z=0.593) are well-studied VLBI sources (e.g. Piner et al. 2003, Klare et al. 2003) and are ideal targets for this study because of their bright pc-scale jets. Figures 1 & 2 show selected images from our first-epoch observations. The 5 GHz VSOP images of 3C 345 previously appeared in Moellenbrock, Roberts, & Wardle (2000).

Although the addition of the spacecraft mitigates the resolution issue in our study, the non-simultaneity (5 days for 3C 279 and ~2 months for 3C 345) of the VLBA only and VSOP observations hampers a direct comparison of the images because of flux variability; we plan to resolve this by extrapolating from other
contemporaneous data. We aligned the images using well-defined optically thin features in the jets as labeled in the figures. The proper motion of C4 in 3C 279 (0.4 mas/yr; Homan et al. 2003) does not compromise the image registration over the 5 day difference between observing epochs, and assuming a typical motion of \( \sim 0.3 \) mas/yr (Ros, Zensus, & Lobanov 2000), the shift in 3C 345 is only \( \sim 1/8 \)th the beamwidth in the jet direction at 5 GHz (Fig. 2).

Once registered, we see in both objects, that the brightest feature at 5 GHz is further downstream from the core than at the higher frequencies, and is not the core itself (seen in the higher frequency images); thus opacity effects are important within our observing bands. In 3C 345, the models (Fig. 1) and polarization maps (Fig. 2) show that the core is almost completely self-absorbed and depolarized at 5 GHz. This may explain the lack of circular polarization in the core at 8.4 GHz, but its detection at 15 GHz (Homan & Wardle 2003). We find also a low rotation measure in the core and jet, as measured previously by Taylor (1998). The 3C 345 spectra also show hints that the jet is beginning to become opaque near 5 GHz – this should become more apparent in the 1.6 GHz VSOP data. Lastly, there is a noticeable shift in the position of its core measured at 5 GHz, with respect to the higher frequency 15 to 43 GHz observations, which
Figure 2. Matched resolution (as in 3C 279; Fig. 1) total intensity [left panel] and polarized intensity with ticks indicating electric field direction [right] images of 3C 345.

can not be reconciled by component motions over the \( \sim 2 \) month elapse between the observations – it would require that all three jet components move more than 3 times faster than typically observed (Ros et al. 2000). Analysis of the L-band VSOP data for both objects are in progress, and observations at other epochs will track variability.

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**References**

Homan, D. C., & Wardle, J. F. C. 2003, ApSS, in Circular Polarisation of Relativistic Jet Sources, eds. R.P. Fender & J.-P. Macquart, in press

Homan, D. C., Lister, M. L., Kellermann, K. I., et al. 2003, ApJ, 589, L9

Klare, J., et al. 2001, in Galaxies and their Constituents at the Highest Angular Resolutions, IAU Symposium 205, ed. R. T. Schilizzi, 130

Moellenbrock, G. A., Roberts, D. H., & Wardle, J. F. C. 2000, in Astrophysical Phenomena Revealed by Space VLBI, eds. H. Hirabayashi, et al., 129

Piner, B. G., Unwin, S. C., Wehrle, A. E., et al. 2003, ApJ, 588, 716

Ros, E., Zensus, J. A., & Lobanov, A. P. 2000, A&A, 354, 55

Taylor, G. B. 1998, ApJ, 506, 637