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A Complete Set of VSOP Observations of 3C279

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Abstract. We have compiled a complete set of VSOP observations of 3C279, consisting of eight 5 GHz, and six 1.6 GHz, VSOP observations, all of which include the VLBA in the ground array. We are using the data-set to determine brightness temperature limits from model-fits to the visibilities, the transverse structure of the jet over its first 20 milliarcseconds, and parsec-scale spectral index maps.

1. Introduction

The radio source 3C279 has been well studied with ground observations over the last 15 years (Piner et al. 2003; Homan et al. 2003; Ojha et al. 2004; Jorstad et al. 2004) with increased interest in the source following its rapid, bright flares at >100 MeV gamma-ray energies (Wehrle et al. 1998).

VSOP observations 3C279 were made between January 1998 and January 2001 as part of the proposals v147, w094, and w088. A log of the observations is given in Table 1. The first epoch observations were described in Edwards et al. (1999), Hirabayashi et al. (2000a), and Piner et al. (2000a, 2000b). Second epoch observations described in Hirabayashi et al. (2000b). A priori calibration and fringe fitting of all data was carried out in AIPS, and images produced in Difmap.

2. Images

The 5 GHz VSOP images are dominated by the compact core and inner jet and a bright component at 4 mas from the core (see Figure 1). The jet component, labeled C4, has been followed since its ejection in late 1984. Jorstad et al. (2004) present a high-resolution multi-epoch VLBA study of this inner jet region.

The 1.6 GHz images show the core and C4 and a more diffuse jet to the southwest. Strongly tapering the image to provide maximum sensitivity to more diffuse emission (effectively excluding the space baselines) allows the jet to be

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Table 1. Observation Log

Observation code	Date	Frequency (GHz)
v147a	1998 Jan 09	1.6
v147b1	1998 Jan 10	4.8
w094b1	1999 Mar 15	5.0
w094b2	1999 Apr 09	4.8
w088d1	1999 Apr 14	1.6
w094b3	1999 May 12	4.9
w088d2	1999 Jun 26	1.6
w094b4	1999 Jul 06	4.9
w094b5	2000 Mar 30	4.8
w094b6	2000 Mar 31	4.9
w088d3	2000 Apr 01	1.6
w088d4	2000 Apr 02	1.6
w094b7	2001 Jan 10	5.0
w088d5	2001 Jan 11	1.6

traced out to ∼100mas from the core, connecting it to the innermost jet structure observed in VLA images (de Pater and Perley 1983).

3. Brightness Temperatures

Model-fitting of the images was performed in VSOP_DIFMAP with HALCA data up-weighted to contribute equally to the ground data (Lovell et al. 2004). Errors on the size and flux density of the Gaussian components were determined using the DIFWRAP package (Lovell 2000). Brightness temperatures and lower limits were computed from these models. The median brightness temperature lower limits for the core were 2.3×10^{12} K at 1.6 GHz and 4.4×10^{12} K at 5 GHz. For C4, the median brightness temperature lower limits were 1.0×10^{12} K at 1.6 GHz and 3.7×10^{12} K at 5 GHz.

4. Spectral Image Maps

Spectral index maps were produced using the 1.6 GHz VSOP images and the 5 GHz VLBA-only images as these have nearly matched resolutions.

There were five epochs at which observations at both frequencies occurred within a 10 day period. Images were aligned on the peak of C4 to avoid the effects of the expected frequency-dependent core shifts in the core.

The spectral index at the eastern-most end of the core region approaches the theoretical limiting value for synchrotron self-absorption of α=2.5 (for $S \propto \nu^{+\alpha}$), implying a very compact core region. Images will be presented elsewhere.

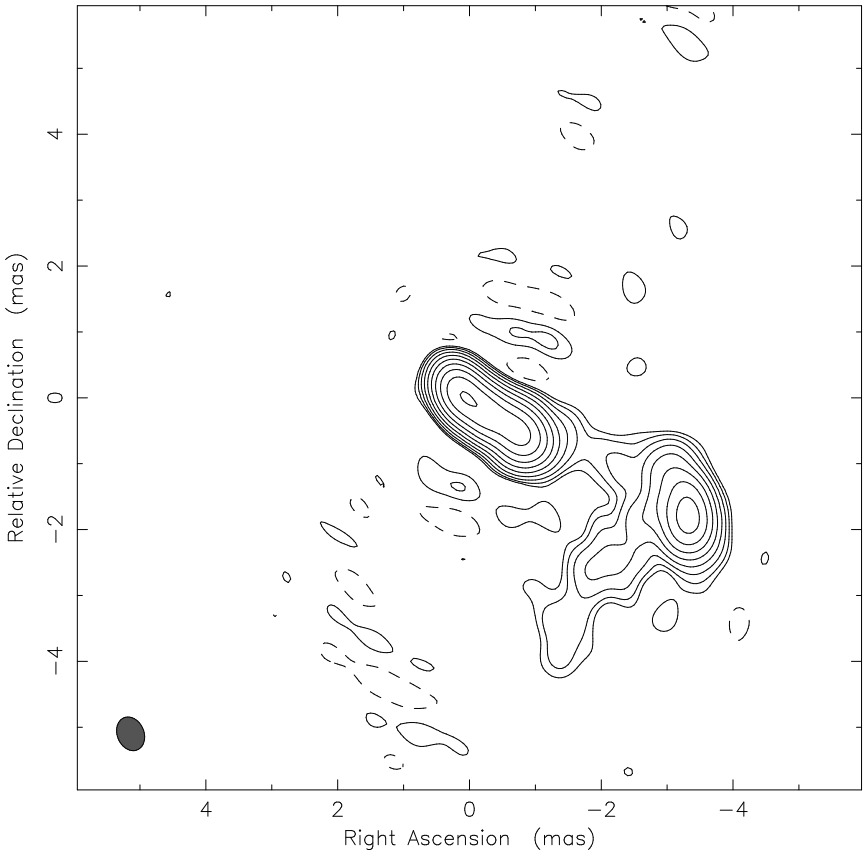

Figure 1. VSOP image of 3C279 at 4.8 GHz from 2000 Mar 30. Image peak is 4.5 Jy/beam; contour levels are −1, 1, 2, ..., 512 times 8.3 mJy/beam; beam FWHM is 0.5×0.4 mas at a position angle of 23°.

5. Jet Transverse Structure

The high-resolution 1.6 GHz images allow the transverse structure of the jet to be resolved from about 10 to 20 mas from the core. While some cuts show the signature of limb-brightening, overall the brightness maximum is statistically no more likely to occur at the edge or in the center, suggesting a more complex brightness distribution than the simplest inner-spine–outer-sheath models. A sample of transverse cuts is shown in Figure 2. Full details will be presented elsewhere.

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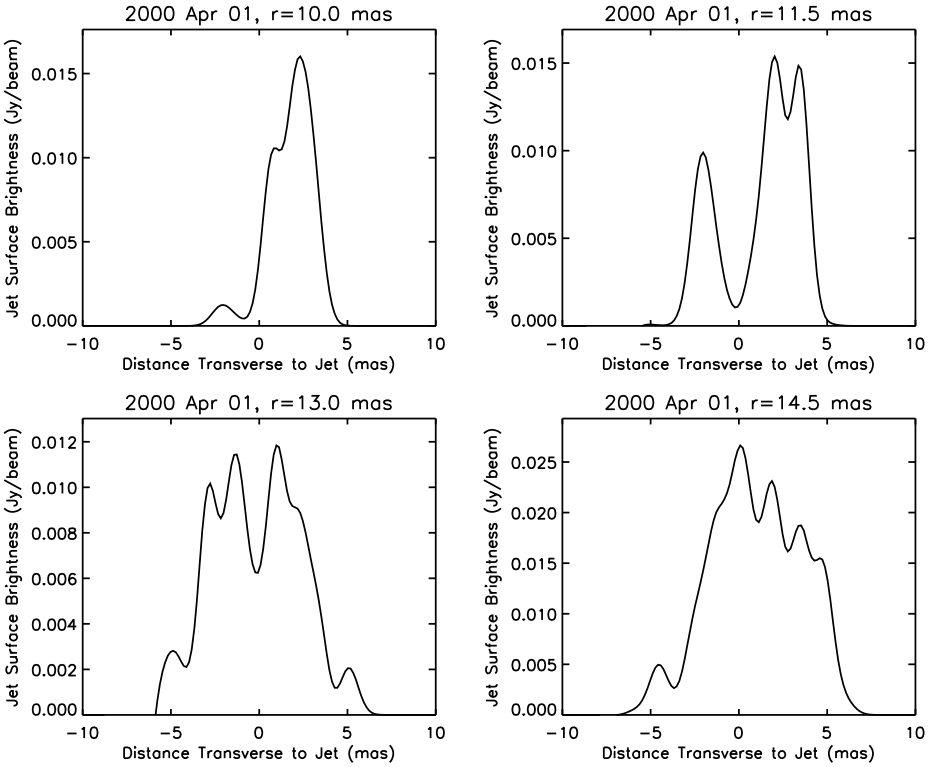

Figure 2. Transverse cuts across the jet made in the 1.6 GHz VSOP image of 3C279 from 2000 Apr 1, showing the variety of profiles observed.

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