Astrophysical Phenomena Revealed by Space VLBI
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VSOP Studies of the Bright Radio Source PKS 1921−293

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Abstract

We (for collaborators see acknowledgements) present a preliminary report on VLBI Space Observatory Programme (VSOP) observations of one of the brightest radio sources, PKS 1921−293, at both 1.6 and 5.0 GHz. With the high-resolution provided by HALCA, we are able to look deeper into the core region. An inner jet component about 1.5 mas to the core is revealed for the first time. The core brightness temperature (in the rest frame of the quasar) is estimated of 3.0×10^{12} K.

1 Introduction

The quasar PKS 1921−293 (OV−236) is a relatively nearby radio-loud blazar with $m_v = 17.5$. It is one of the strongest radio sources in the sky. Figure 1 shows a composite spectrum of PKS 1921−293. Despite its dramatic variability over a wide range of wavelengths from radio to X-ray, its spectrum is quite simple: a flat radio spectrum over 3 orders of magnitude (from ∼300 MHz to ∼300 GHz) plus a power-law spectrum with a slope of −1.3 from infrared to X-ray. If this power law spectrum extends to $\gamma-$ray band, the extrapolated flux at 100 MeV is about 1.1×10^{-13} Jy. This is lower than those of EGRET sources (see Figure 5 in von Montigny et al. 1995), which might be the simplest explanation to the non-detection of $\gamma-$ray emission from the source.

The compactness of PKS 1921−293, implied by its flat radio spectrum, has been confirmed by existing VLBI measurements. It is not resolved on arcsecond scales with VLA observations (de Pater et al. 1985). Previous VLBI observations suggest a very compact bright core with a brightness temperature (T_b) measured in the rest frame of the quasar, in excess of 10^{12} K, which is among the highest measured for any blazar (cf., Linfield et al. 1989; Moellenbrock et al. 1996).

At a redshift of only 0.352 (Wills and Wills 1981), an angular resolution of 1 mas corresponds to a linear resolution of 4.6 pc (assuming $H_0 = 65\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ and $q_0 = 0.5$).

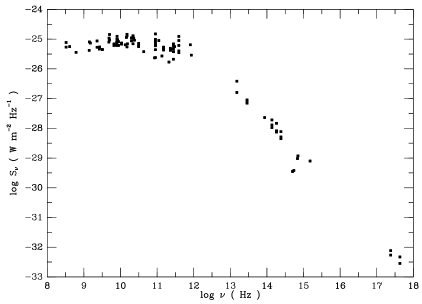

Figure 1: The composite spectrum of PKS 1921−293 obtained from various published and unpublished measurements.

2 VSOP Observations

VSOP observations of PKS 1921−293 have been performed at two epochs. On 1997 July 18, VSOP in-orbit checkout observations of PKS 1921−293 were made with interleaved 1.6 and 5.0 GHz scans. The data were recorded in standard VLBA format, but with only one intermediate-frequency (IF) band of 16 MHz for each frequency. On 1998 June 19, PKS 1921−293 was observed at a frequency of 5.0 GHz with a recording bandwidth of 32 MHz (two IFs). NRAO's VLBA and phased VLA provided the ground array for these observations. These data were correlated in Socorro. The total durations of these observations were about 3.0 hr in 1997 (1.5 hr for each frequency) and 7.5 hr in 1998 (at 5.0 GHz). Figure 2 shows the (u, v) coverage for each epoch.

Post-correlation data reduction was performed within AIPS and Difmap. Strong fringes were consistently detected on all space baselines to HALCA. In order to explore the compact core region, uniform weighting was adopted for the VSOP images.

3 Results

The details of 1.6 GHz VSOP imaging are given in Shen et al. (1999). The analysis of the 5.0 GHz data is still ongoing. We show preliminary images from two-epoch 5.0 GHz VSOP observations in Figure 3 along with the plots of visibility amplitude versus (u, v) distance.

The core-jet morphology of VSOP images is consistent with ground-based VLBI images, consisting of a very strong and compact core with some extended jet emissions (cf. Kellermann et al. 1998). Moreover,

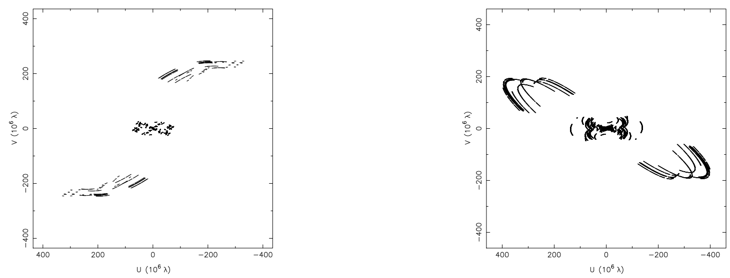

Figure 2: The (u, v) coverage corresponding to VSOP observations of PKS 1921−293 on 1997 July 18 (*left*) and 1998 June 19 (*right*).

the addition of data from HALCA has greatly improved the angular resolution, especially along the north-south direction for this southern source (7-times better at the first epoch, see Figure 2). As a result, we are able to look deeper into the core region than ever before at 1.6 and 5.0 GHz. For the first time, a new inner jet component was revealed at about 1.5 mas north to the 1.6 GHz core. This feature is also seen in the 1998 5.0 GHz image with a little shift to the east. So, it may be moving on a common curved path connecting the jet within a few parsecs to the 10-parsec-scale jet seen in VLBA images (Shen et al. 2000, in preparation).

The distribution of the correlated flux density versus (u, v) distance indicates that the core is partially resolved on space baselines. A dip seen in 1997 5.0 GHz data at ~250 Mλ (Figure 3 top) may suggest the existence of the compact double separated by ~0.4 mas along the position angle of HALCA baselines within the core. Unfortunately, there was a ~90° change in the position angle for the 1998 observations (see Figure 2), which made it difficult to discern any double structure. But the non-monotonic decrease in the correlated flux density (Figure 3 bottom) implies that the central region cannot be fitted with a single circular component. The derived core T_b from both 1.6 and 5.0 GHz images is about 3.0×10^{12} K, an indication of relativistic beaming.

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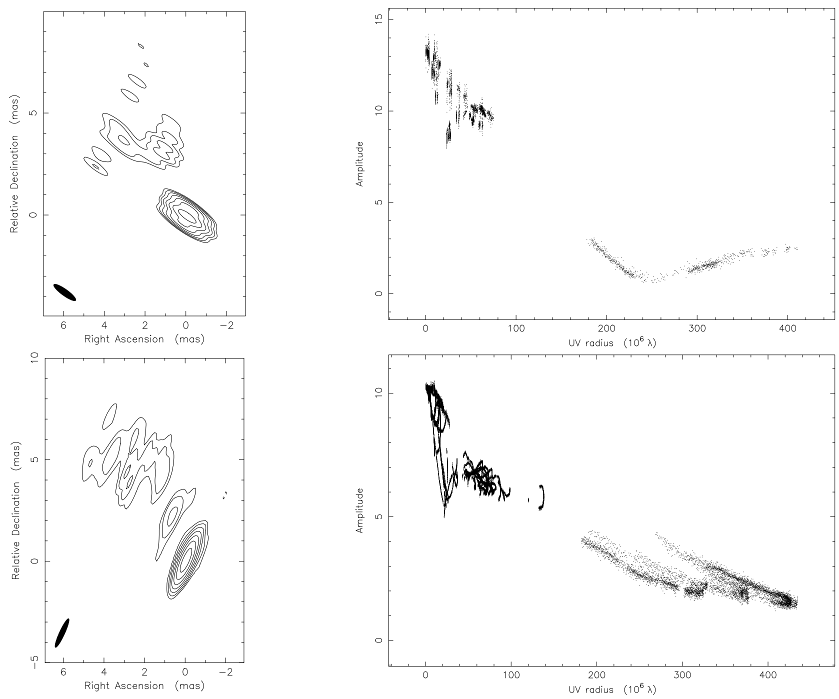

Figure 3: 5.0 GHz VSOP images and plots of visibility amplitude vs. (u, v) distance from the two epochs (Top: 1997 July 18; Bottom: 1998 June 19). Contour levels are at -1, 1, 2, 4, 8 and 64% of the peak flux densities, which are 5.3 Jy/beam and 4.1 Jy/beam for the two images respectively. The synthesized beams are 1.32×0.32 (mas) at 54.3° and 1.55×0.26 (mas) at $-24.7°$, respectively.

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