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VSOP Imaging of the Southern Blazar J1924-29 at 18 cm

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Abstract. We present preliminary results of the VSOP imaging of the nearby southern blazar J1924-29 at 18 cm. The high resolution image shows that the source possesses a core-jet structure along the northeast direction. The brightness temperature of the core in the rest frame of the quasar is 1.18×10^{12} K.

1. Introduction

On 1997 February 12, the Institute of Space and Astronomical Science (ISAS) launched the HALCA satellite carrying an 8 m telescope dedicated specifically to VLBI. With an apogee height of 21400 km, radio sources were able to be imaged with angular resolution three times greater than that with ground arrays at the same frequency (Hirabayashi et al. 1998). In particular, the addition of HALCA significantly improves the north-south resolution for equatorial and southern radio sources. The high resolution of VSOP also provides almost an order-of-magnitude increase to the detectable brightness temperature (from $10^{11} - 10^{12}$ K to $10^{12} - 10^{13}$ K for bright sources) in comparison to the ground-only observation (Shen et al. 1999).

The southern blazar J1924-29 (OV-236) is one of the strongest radio sources in the sky, but it was not detected by EGRET in greater than 100 MeV gamma-rays (Fichtel et al. 1994). It is a highly polarized and optically violent variable quasar at a redshift of z=0.352, with m_v = 17.5 (Wills &Wills 1981). It is also known as a RBL object (Hewitt & Burbidge 1993). According to the data from the UMRAO (University of Radio Astronomy Observatory) database, the total flux density at cm wavelength can go up to as high as 25Jy and go down as low as 5 Jy. Despite its dramatic variability over a wide range of wavelengths from radio to X-ray, its spectrum is quiet 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 (Ghosh et al. 1995). The existing ground VLBA observations reveal a core-jet structure (Kellermann et al. 1998). Its core is very compact, with a brightness temperature in the rest frame of the source greater than 10^{12} K (Shen et al. 1999). The jet moving along a curved trajectory superluminally ends up in a diffuse component about 15 pc from the core (Tingay et al. 1998).

2. Observation and results

The observation of the southern Blazar J1924-29 was carried out on 2000 July 6 from 4:00 UT to 12:00 UT. We used the complete VLBA (ten 25 cm antennas) and the Japanese satellite HALCA (8 m) at 18 cm. Two tracking stations, Green Bank (USA) and Tidbinbilla (Australia), received the data from HALCA. The data includes the sampling when HALCA passed through the apogee point (at 5:48:00 UT) as well as the perigee point (at 8:57:00 UT). And we achieved a relatively good *uv*-coverage. As showed in Fig. 1 a, the denser set of points with *uv*-distance less than 20 $M\lambda$ corresponds to ground-based baselines. The outer tracks correspond to baselines to HALCA. The cross-correlation of the data was carried out on the VLBA correlator in Socorro, New Mexico (USA).

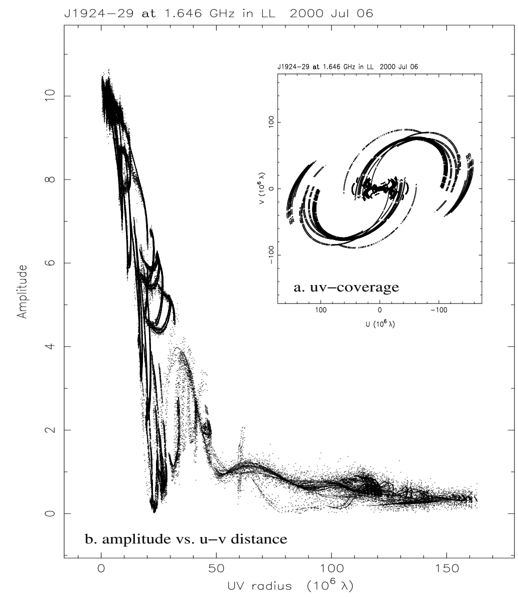

Fig. 1. (a) The *uv*-coverage (b) A plot of amplitude vs. *uv* distance

We used the NRAO AIPS (Astronomical Image Processing System) package for the data reduction and the Caltech imaging program DIFMAP (Shepherd er al. 1995) to make the maps. In order to have a general understanding about the source structure, we first made an image from the ground VLBI data only. The imaging was shown in Fig. 2. It is elongated to the northeast, consistent with the previous ground-based VLBI results.

Along with the data from space telescope HALCA, more than three times improvement in north-south resolution can be achieved, which enables a close look at the compact core of J1924-29. To ensure a better angular resolution a gaussian taper

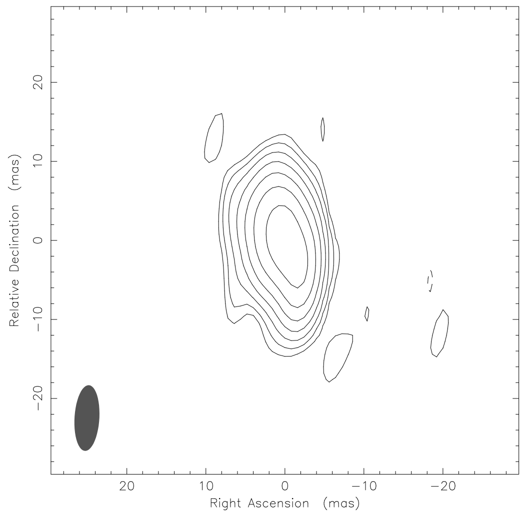

Fig. 2. J1924-29 image made from the ground VLBA data only. The peak brightness is 4.35 Jy/beam, contour levels are: $0.04 Jy/beam \times (-1, 1, 2, 4, 8, 16, 32, 64)$, with a synthesized beam size of $8.33 mas \times 3.14 mas$ at $-3.41°$

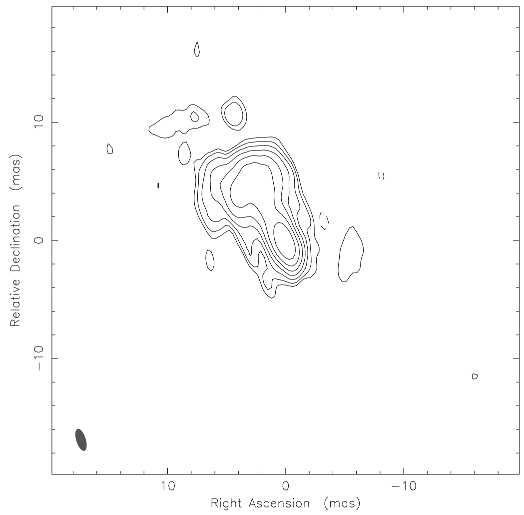

Fig. 3. An 18 cm VSOP image of J1924-29 made from VLBA and HALCA. The peak brightness is 1.30 Jy/beam, contour levels are: $0.01 Jy/beam \times (-1, 1, 2, 4, 8, 16, 32, 64)$, with a synthesized beam size of $1.95 mas \times 0.809 mas$ at 17.3°

function (Selftaper in Difmap) was taken to weight down short baselines, and the space-ground baselines contributed about 50% of the effective data used for the images. The resultant image is shown in Fig. 3. As expected, the source is resolved and appears a typical core-jet morphology. For comparison, the map with uniform weighting was also made; both are consistent with each other. The source can be fitted with a model consisting of three circular Gaussian components. The result is shown in table 1. Assuming $H_0 = 65\ kms^{-1} Mpc^{-1}$ and $q_0 = 0.5$, these two components lie to the northeast with a separation of 7.4 pc and 27.1 pc away from the core, respectively. And there are about 10° difference between the position angles of the outer and inner jet components.

Table 1. Model fitting to the vsop image of J1924-29

Component	S (Jy)	r (mas)	θ (°)	R (mas)
1	2.49	0	0	1.16
2	1.07	1.60	18.6	1.06
3	5.89	5.07	28.6	3.73

Notes S: the flux density of each component; (r, θ): the distance and position angle of each component with respect to the component 1; R: the radius of the circular component.

From the model fitting to the visibility data, the brightness temperature of the core in the rest frame is $1.18 \times 10^{12} K$. This should be a lower limit to the core brightness temperature since the core is not well resolved compared to the resolution of the VSOP observation. Fig. 1 b is the distribution of visibility amplitude versus *uv* distance. The plot shows a dramatic drop from the ground baselines to the space baselines. When the *uv* radius is longer than 130 $M\lambda$ the amplitude of visibility remains almost constant (0.4Jy or so), which infers the the core is still unresolved. It gives the upper limit of the core's size. The value is about 1.29 mas (5.9 pc).

3. Conclusions

The total flux density of J1924-29 is undergoing a dramatic variability at centimeter wavelength. The high resolution image from space VLBI data reveals a typical core-jet morphology in J1924-29. The two jet components lie to the northeast and are about 7.4 pc to 27.1 pc away from the core. And there are about 10° difference between the position angles of the outer and inner jet components, which indicates a curved jet trajectory. Our measurements reveal that the brightness temperature of the core in the rest frame of the source is more than $10^{12} K$.

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