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EVN/Global observations of the Gravitational Lens JVAS B0218+357 at 8.4 GHz

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Abstract. We present new observations of the gravitational lens system JVAS B0218+357 made with a global VLBI network at 8.4 GHz. Our maps have an rms noise of 30 μJy beam^{-1} and high resolution ($\sim$1 mas), permitting us to detect more of the extended structure of the radio jets in the A and B images. We can identify several sub-components common to both images with the expected parity reversal, including a possible counter-jet. We do not detect either the core of the lensing galaxy or any third image. Using a model of the lensing galaxy, we have back-projected both images to the source plane and find that they agree well. However, there are small, but significant, differences and we discuss their possible origins. We find an exponent of the radial mass distribution of $\beta \approx 1.04$, in agreement with results from an independent dataset.

1. B0218+357 and H_0

Gravitational lenses have for many years now been recognised as important tools for estimating the value of the Hubble parameter. One of the best systems for this is B0218+357, a lens system that was discovered during the JVAS survey in 1992 (Patnaik et al. 1993). It comprises two images of the core of a $z = 0.96$ (Lawrence 1996) quasar and an Einstein ring (Biggs et al. 2001). It is particularly suitable for H_0 determination because both the (source and lens) redshifts and the time delay are known (Biggs et al. 1999) and because the lens is a single isolated galaxy (Lehár et al. 2000). VLBI observations can be used to constrain the lens model by mapping the extended structures in each image on mas scales.

2. EVN/Global VLBI Maps

B0218+357 was observed at 8.4 GHz in November 2000 with a 17-telescope global VLBI array which included the phased VLA and two 70-m telescopes of the DSN. The final maps of Image A and image B are shown in Fig. 1 and have a resolution 1.36 × 0.41 mas and an off-source rms noise of 30 μJy beam^{-1}. These maps reveal much more structure associated with A and B than was previously known.

Image B is made up of two bright sub-components and a radio jet extending 10 mas to the east. Image A looks very different to B, but this is because it is tangentially stretched by the action of the lens, an effect that is predicted by lens models of this and other systems, but which is seen most dramatically in B0218+357. Also detected is what may be a counter-jet to the west of the core. This, and other features in the map, illustrate the phenomenon of parity reversal. Notice that the counter-jets in A and B lie on opposite sides of a line joining the sub-components 1 and 2. This effect is also evident in the “jet1” and “jet3” regions. No evidence was found for either a core associ-

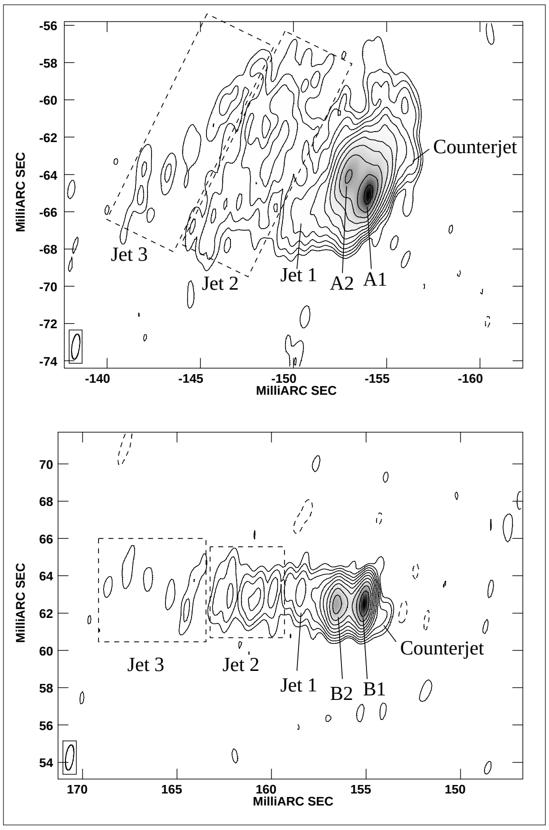

Fig. 1. Global VLBI images of images A (top) and B (bottom) of B0218+357.

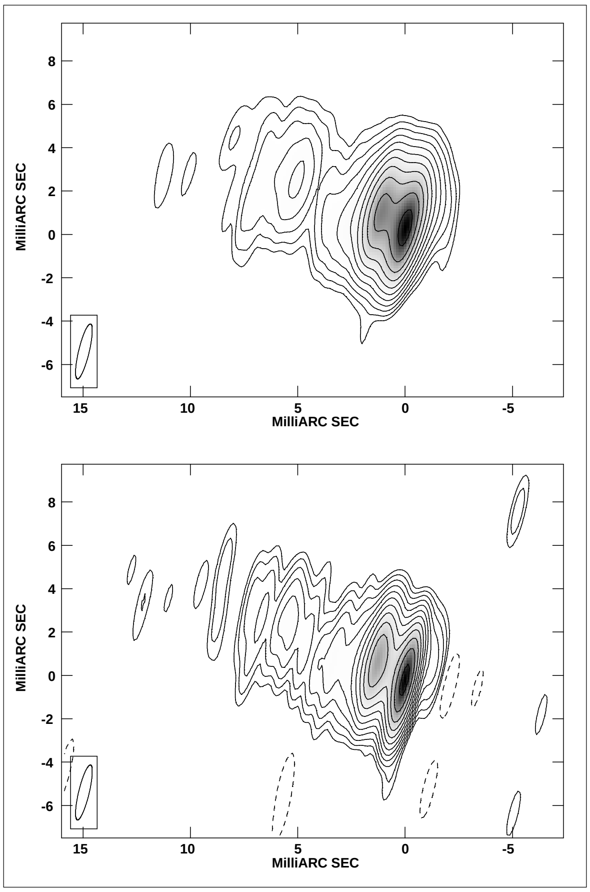

Fig. 2. Back-projected maps of image A (top) and image B (bottom).

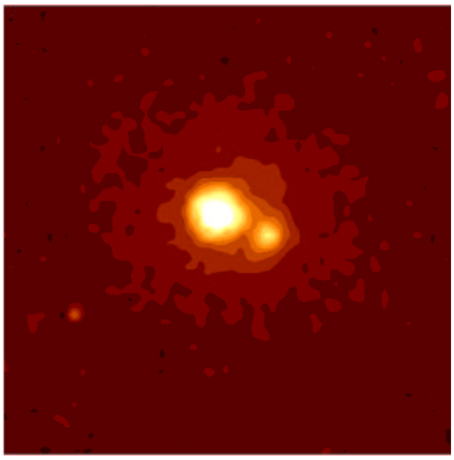

Fig. 3. *HST I*-band image of B0218+357.

ated with the lensing galaxy or the third image (which is usually presumed to be rendered undetectable due to the finite core radii of lensing galaxies).

3. Constraining the Lens Model

Eventually these data will be used to improve our model of the lensing galaxy using the LensClean technique. In the meantime a simple model has been used to back-project both of the images into the source plane. If the model is correct then both images should look the same.

The back-projection of each image is shown in Fig. 2 with image A at the top. The model is successful in removing the gross differences between the images, especially with regard to the orientation and the tangential stretching. The parity reversal has also been removed e.g. the "counter-jet" now lies at a consistent position angle with respect to the core.

A closer comparison of the A and B source-plane maps shows that the B jet seems to be stretched by about 10 per cent relative to A. If we assume a power-law potential for the radial mass distribution, an index of $\beta \approx 1.04$ can naturally account for the observed stretching. This agrees with results from the positions of the sub-components 1 and 2 only, as seen in a higher-resolution 15-GHz VLBA map (Patnaik, Porcas & Browne 1995).

4. Future *HST* ACS Observations

Perhaps the last remaining hurdle to a superlative measurement of H_0 from this system is the position of the lensing galaxy which remains uncertain due to the small separation of the images (334 mas). A previous *HST I*-band image is shown in Fig. 3 (Xanthopoulos, Jackson & Browne 1998). Future observations with the *HST* Advanced Camera for Surveys (ACS) should measure this important parameter with the required accuracy. Our group has been awarded 36 orbits with this instrument.

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