THE PARSEC-SCALE NUCLEUS AND JETS OF HYDRA A

GREGORY B. TAYLOR
NRAO
P.O. Box 0, Socorro, NM 87801

1. Introduction

Sensitive, high-resolution VLBA observations of the nuclear region of Hydra A are presented at 1.3, 5 and 15 GHz. Hydra A (3C218) is an outstanding example of a high-luminosity FRI radio galaxy embedded within a cooling flow cluster. VLA observations by Taylor & Perley (1993) have demonstrated extremely high ($>$5000 radians m^{-2}) Faraday rotation measures (RMs) and a striking RM and depolarization asymmetry between the northern and southern radio lobes. In view of this asymmetry on the kpc-scale Hydra A appears remarkably symmetric on the pc-scale in the radio continuum. Hydra A is also unusual in that the 21 cm atomic Hydrogen line is seen in absorption against the nucleus.

2. Observations

The observations were carried out using the 10 element VLBA of the NRAO[1] on 1995 March 17-18. Both right and left circular polarizations were recorded using 2 bit sampling across a total bandwidth of 8 MHz. The VLBA correlator produced 512 frequency channels in each 4 second integration. The total integration time was ~2.5 hours at each frequency. Amplitude calibration for each antenna was derived from measurements of the antenna gain and system temperature during each run. In addition, the strong calibrator DA193 (0552+398) was observed to refine the amplitude calibration. All editing, imaging, deconvolution, and self-calibration were performed using DIFMAP (Shepherd *et. al*, 1995).

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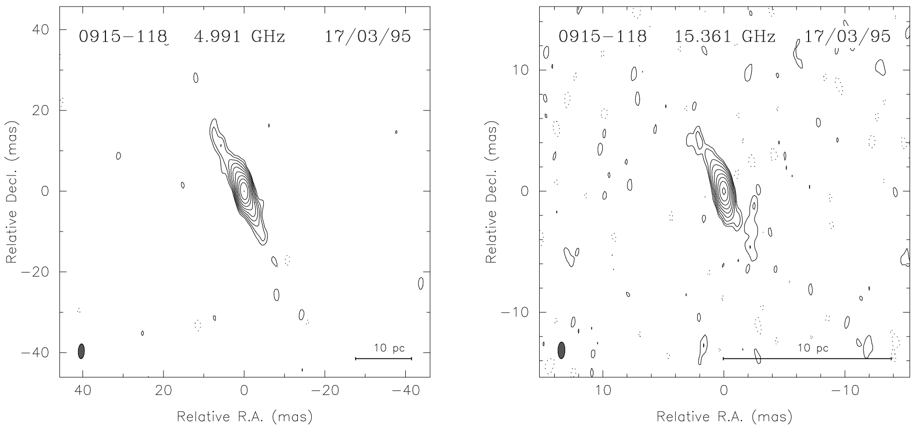

Figure 1. **a.** The nucleus of Hydra A at 5 GHz. Contours are drawn at −0.3, 0.3, 0.6, 1.2, 2.4, 4.8, 9.6, 19.2, 38, 77, and 154 mJy/beam where the beamsize is 3.66 × 1.53 mas in p.a. −3°. **b.** The nucleus of Hydra A at 15 GHz. Contours are at −0.5, 0.5, 1, 2, 4, 8, 16, 32, 64, and 128 mJy/beam where the beamsize is 1.38 × 0.58 mas in p.a. −1°.

3. Results and Discussion

Fig. 1a shows the 5 GHz VLBA image of the nucleus of Hydra A at ∼2 mas resolution. The jet is straight along a position angle of 30° and symmetric about the core with a jet-to-counterjet ratio of 1.12. The northern side, being slightly stronger, is denoted the "jet" side, and the weaker southern jet the "counterjet" side. The jet-to-counterjet ratios are taken from the integrated flux ratios after removal of the core component. Fig. 1b shows the 15 GHz VLBA image at a resolution of ∼1 mas. The inner jet shown in this image is oriented along a position angle of 23°, and gradually curves to match the orientation angle of 30° seen at 5 GHz. The jet-to-counterjet ratio at 15 GHz is 1.15.

Hydra A is only the second FRI source, the first being 3C338 (Feretti *et. al*, 1993), discovered to have symmetric emission on the pc-scale. If all jets start out relativistic and the jet-to-counterjet ratios are ascribed purely to Doppler beaming effects, then such low jet-to-counterjet ratios are expected only for sources very close to the plane of the sky. Observations of the large-scale RM asymmetries in Hydra A predict an inclination angle of 48°(Taylor & Perley, 1993). While this discrepancy can be explained by a large bend between the inner jet and the lobes, this seems unlikely. On the kpc scale, the jet-to-counterjet ratio at 5 GHz is 1.9.

HI was first detected in absorption towards the nucleus of Hydra A by G. Taylor in 1991. Dwarakanath *et. al* (1995) made higher resolution VLA observations confirming this result, and suggested that the HI gas is distributed in a disk within the central few kpc of the galaxy. Here I

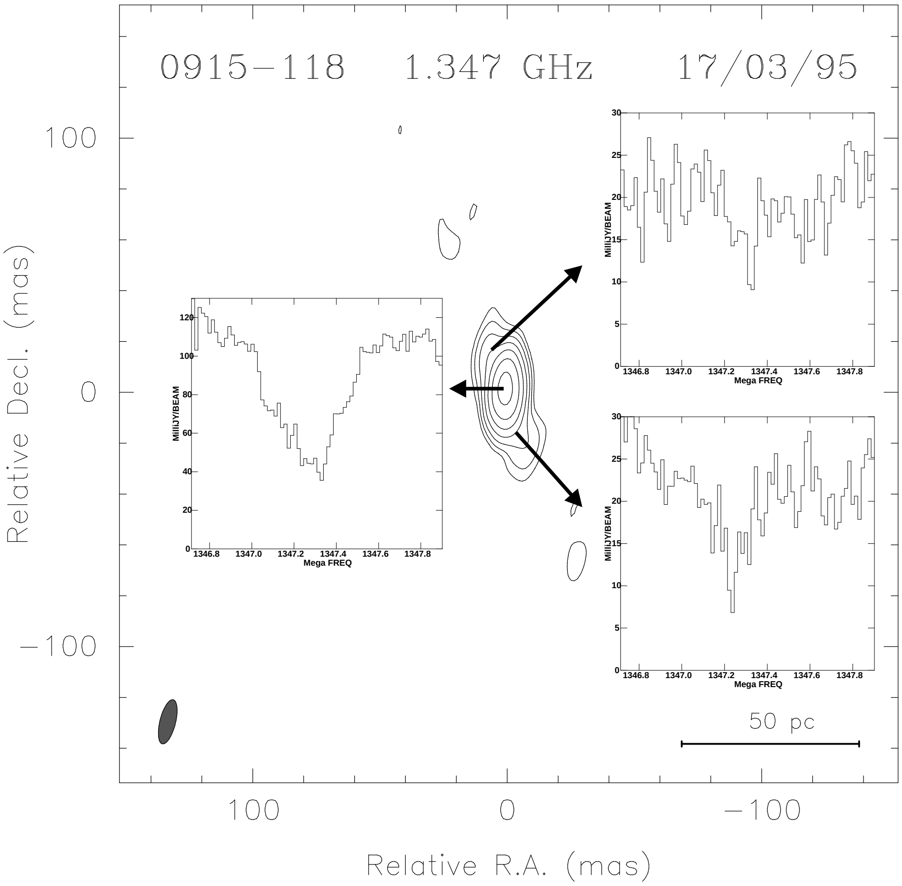

Figure 2. HI absorption against the nucleus of Hydra A. Contours are at −1, 1, 2, 4, 8, 16, 32, and 64 mJy/beam with a beam size of 18 × 6 mas in p.a. −14°. The total velocity spanned by the inset figures is 250 km s^{-1} with a spectral resolution of 3.5 km s^{-1}.

present spatially resolved HI absorption detected against the core and jets of Hydra A (Fig. 2). The two spectra from the northern and southern jet are seperated by 23 mas (17 pc), and show aborption peaks shifted by 20 km s^{-1}. The aborption to both the north and south is also considerably more narrow (∼35 km s^{-1}) than towards the core (∼80 km s^{-1}). These observations support the presence of a disk with a thickness of ∼20 pc.

References

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