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The nuclear environment of the water megamaser radiogalaxy 3C 403

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Abstract. So far, few direct sub-arcsecond resolution studies exist of the dense material that, according to the standard unified scheme, should obscure the central engines of radio galaxies. In the following, observations are presented that highlight the nuclear environment of the prototypical X-shaped FR II galaxy 3C 403. To date, it is the only powerful radio galaxy known to host a water megamaser.

Keywords. masers, galaxies: individual (3C 403), galaxies: active

1. Introduction

The standard unified scheme requires the presence of high column densities of absorbing material obscuring the central engines of active galactic nuclei. To date, few direct sub-arcsecond resolution studies of this gas have been performed toward radio galaxies. Tarchi *et al.* (2003) reported the detection of luminous maser emission from the FRII radio galaxy, 3C 403, providing a suitable target for such investigations. 3C 403 is located at a distance of ~230 Mpc. Optically, it has a normal elliptical structure (Govoni *et al.* 2000), while at radio frequencies it has a remarkable X-shape with "wings" of ~ 100 kpc stretching toward the NW, SW, NE, and SE (e.g. Black *et al.* 1992; their Fig. 13). To better investigate the nuclear environment of this galaxy, the maser detection of Tarchi *et al.* (2003) has been followed-up by us through a number of radio observations at different frequencies. A summary of the main results obtained is reported in the following section.

2. Results and discussion

Our 22 GHz VLA A-array spectral line and continuum maps suggest that the positions of line emission from the maser features and continuum emission from the core are aligned within $0\farcs1$ (110 pc; Fig. 1 and left panel of Fig. 2). The 5 GHz VLBI continuum observations (Fig. 2, right panel) allows analysis of the spatial structure of the nuclear environment at the parsec scale, which supports a situation where a nuclear core, represented by the dominant central radio continuum component, is accompanied by a jet and counterjet directed toward the western and eastern large scale lobes of the galaxy. In view of the statistical properties of the sample of known megamaser galaxies, an association between the maser emission and an accretion disk seems to be the most plausible scenario, with the two main velocity components (Fig. 1) representing the two tangentially seen parts of the masing disk. However, the small velocity difference between

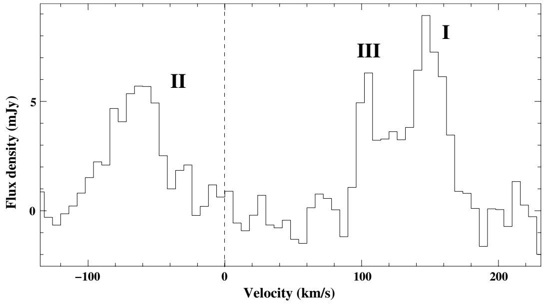

Figure 1. The main water maser features in 3C 403 observed with the VLA A-array on July 23, 2003. The dashed vertical line marks the nominal systemic velocity of the galaxy, $V_{sys} = cz = 17688\,km\,s^{-1}$.

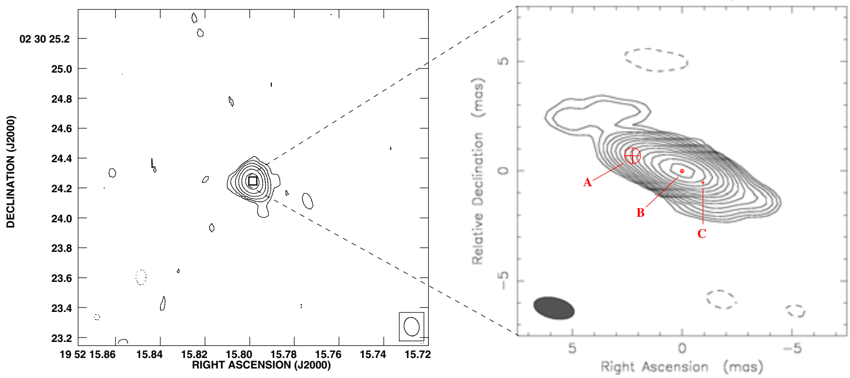

Figure 2. *Left panel:* A naturally weighted 22 GHz VLA radio continuum image (resolution: 0.″1, corresponding to 110 pc) of the nuclear region of 3C 403 made using channels free of line emission. The peak is at 40 mJy beam^{-1}. The contours are (–1, 1, 2, 4, . . ., 32) × 0.75 mJy beam^{-1}. *Right panel:* Full resolution EVN image of the nucleus of 3C 403 at λ=6 cm. The contours start at 0.2 mJy and increase with a factor of 1.5. The beam size of the observations is 1.87 mas×0.94 mas at a position angle of 76.°9.

the two features makes this interpretation questionable. Investigations of J=1-0 and 2-1 transitions of CO using the IRAM 30-m telescope at Pico Veleta in order to detect the thermal emission from a spatially extended molecular environment were unsuccessful. Our ongoing single-dish 1.3 cm monitoring campaign of the maser lines performed with the Effelsberg and the GBT radio telescopes indicates strong variations in the intensities of the two main maser components with (isotropic) luminosities sometimes surpassing 1000 solar luminosities. Typical timescales of the variation are of order 1–2 years.

References

Black, A. R. S., Baum, S. A., Leahy, J. P., Perley, R. A., Riley, J. M., & Scheuer, P. A. G. 1992, *MNRAS* 256, 186

Govoni, F., Falomo, R., Fasano, G., & Scarpa, R. 2000, *A&A* 353, 507

Tarchi, A., Henkel, C., Chiaberge, M., & Menten, K. M. 2003, *A&A* (Letters) 407, L33