PROCEEDINGS OF SCIENCE

The VLBI morphology of M 81* at 43 GHz

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The radio source M 81* at the core of the nearby spiral galaxy M 81 is a low-luminosity active galactic nucleus. The close distance of 3.63 Mpc allows its morphology to be studied in great detail. Here we present preliminary results from continuum λ7 mm VLBI observations of its core, using phase-referencing techniques. These observations set constrains on the size of M 81* at this frequency and enable us to test the frequency dependence on its physical properties.

The 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting
September 23-26, 2008
Bologna, Italy

PoS(IX EVN Symposium)090

1. Introduction

At the heart of the nearby galaxy M 81 (B0951+693, J0955+6903, NGC 3031; $D = 3.63$ Mpc), the low-luminosity ($10^{37.5}$ erg s^{-1}) radio source M 81* is one of the closest active galactic nuclei (AGN). This object is four orders of magnitude brighter than Sgr A*, but has similar shape and polarization properties. M 81* shows a stationary feature in its structure with a jet to the northeast (seen at λ3.6 cm; [1]). Its size follows the law $\theta \propto \nu^{-0.8}$ between 2.3 GHz and 22 GHz. It shows also a frequency-dependent orientation with its position angle (P.A) varying from $\sim$40° at 22 GHz to $\sim$75° at 2.3 GHz [2]. M 81* is variable at all wavebands, and presents relativistic X-ray iron lines at X-rays [1].

2. Observations and data analysis

We observed M 81* on September 13, 2002 with the complete Very Long Baseline Array at a frequency of 43 GHz (λ7 mm). Observations were performed in phase-referencing mode, using the BL Lac object B0954+658 (J0958+6533; z=0.368), 34 arcmin apart on the sky. After calibration, the first FRING run (NL was used as reference antenna) on the target source provided a 65% failure in the overall solutions, while an 80% of successful fringe detection were obtained for the reference source. Hybrid mapping was performed for the calibrator source using DIFMAP. The resulting self-calibration solutions for the amplitude were applied to the M 81* data back in AIPS. A run of IMAGR in AIPS was performed, yielding an image. The CLEAN table of those was used as input in FRING to make structure-free delay and rate solutions. Using these values we restricted the search windows for delay and rate in M 81*, and we applied FRING again, providing very satisfactory results. We then were able to perform a hybrid map of M 81*, shown in Figure 1. Our image provides hints of extended emission to the north-east, in agreement with [1].

3. Discussion

We also model fitted the visibility data of M 81* with a Gaussian elliptical function. The source has an elliptical shape extended in the north-east–south-west direction. The major axis of the function is of 93±1 μas, with an axis ratio of 0.3±0.1. We used the model fitted size of our target source to compare it with earlier measurements. A power-law fit to the sizes as a function or frequency, (including the epoch-averaged measurements by [3, 4]) together with our measurement shows a dependence of $\theta \propto \nu^{-0.88\pm0.05}$. These results are compatible with the ones previously reported by [2].

Our observations have resulted in the detection of M 81* at the shortest wavelength performed with VLBI so far. Further observations are needed to discern the nature of the jet in M 81*. Future monitoring observations could also trace any structural changes and/or proper motions in the jet.

Acknowledgments MAPT is funded by a Ramón y Cajal contract of the Spanish Ministry of Education. The Very Long Baseline Array is operated by the USA National Radio Astronomy Observatory, which is operated by Associated Universities Inc., in cooperative agrement with the USA National Science Foundation.

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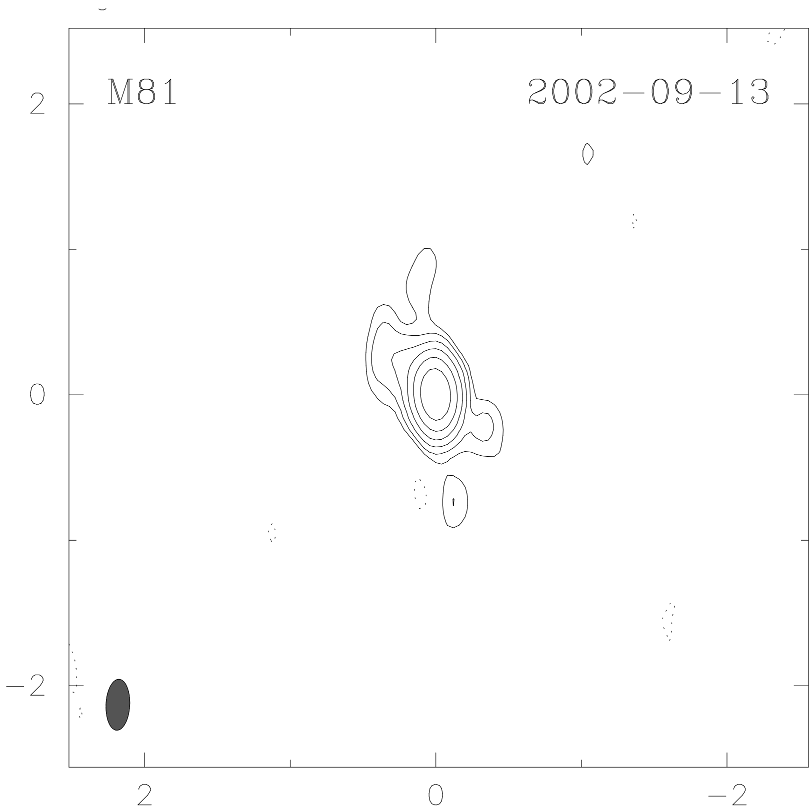

Figure 1: Hybrid contour map of M 81* from the self-calibrated data set (see Text). The lowest contour is of 1.57 mJy beam^{-1}. The peak of brightness is of 98.5 mJy beam^{-1}. The beam size, shown at the bottom, left, is of 0.351×0.164 mas, in P.A. 2.6°.

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