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Sub-arcsecond radio jets in the high mass X-ray binary LS I +61 303

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Abstract. We present four runs of MERLIN observations of LS I +61 303 carried out from February to May 2001. We have detected a jet extending up to ∼400 AU, aligned with the previously discovered structure of few AU found at higher resolution with the EVN.

1. Introduction

The high mass X-ray binary system LS I +61 303 exhibits strong radio outbursts with a 26.5 d period (Taylor & Gregory 1982). This periodicity, also present at other wavelengths (X, IR, Hα), corresponds to the orbital period of the system (Hutchings & Crampton 1981; references in Massi et al. 2001). The radio outbursts occur mainly in the phase range 0.6–0.8. (Gregory 2002). The flux density decay of the outbursts is well fitted by a model of an adiabatically expanding cloud of synchrotron-emitting relativistic electrons (Taylor & Gregory 1982; Paredes et al. 1991).

2. Morphology at milliarcsecond scales

Radio observations with global VLBI and with the EVN at 6 cm wavelength (Fig. 1 Top) have resolved the source as an elongated structure of few AU in size with position angle in the range 120°–160°. The variations of the position angle, as well as strong variations in the apparent velocity, suggest a precessing jet. The intrinsic velocity has been estimated to be about 0.4c (Massi et al. 2001).

3. MERLIN observations

In order to investigate the existence of eventual features one order of magnitude larger than those "visible" at VLBI scales we used MERLIN to perform four observing runs, ∼15 hour each, at 6 cm wavelength.

In the first run, carried out on February 3 2001, corresponding to a radio phase of 0.78, the flux on the shortest baselines was oscillating from 300 to 450 mJy. Hence the source was in outburst. The obtained map shows an unresolved source at MERLIN scales.

The second run was carried out on April 22 2001, corresponding to a radio phase of 0.73. The obtained map is shown in Fig. 1 (Bottom) where the first contour level is at 3σ=0.3 mJy, (the other contours are: 4, 5, 6, 7, 8, 9,

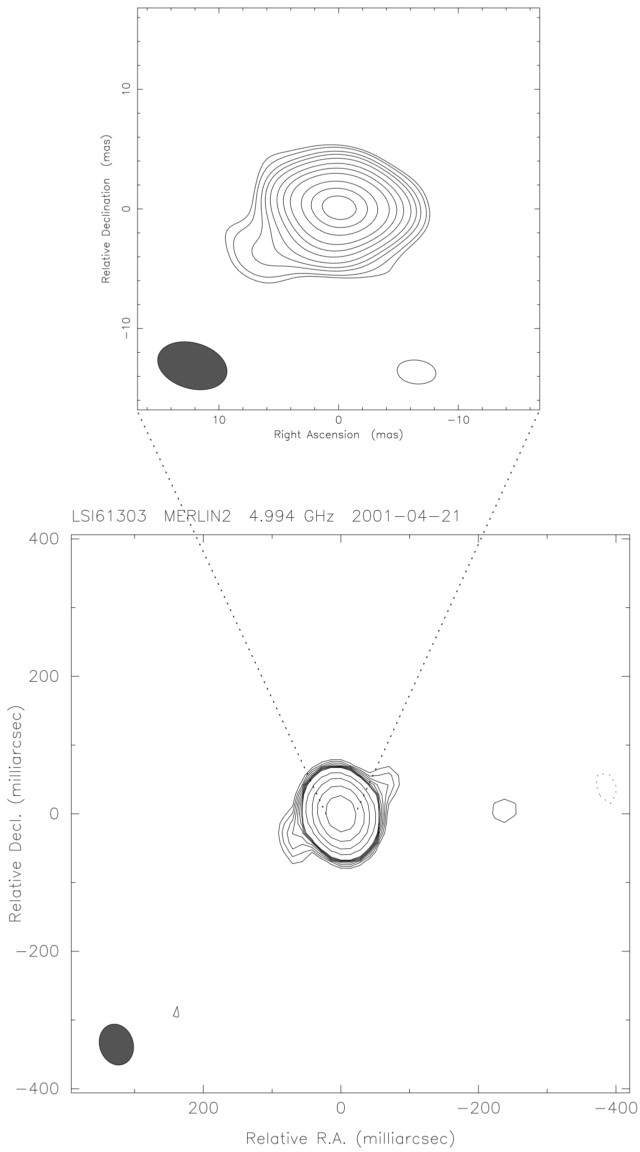

Fig. 1. Top: EVN map obtained on June 7 1994. Bottom: MERLIN map obtained on April 22 2001.

10, 20, 40, 80, 160 and 360σ). An elongated structure of about 200 mas (400 AU) is clearly present and perfectly aligned with the structure at EVN scales shown at the top of the figure. The flux in each jet is less than 1 mJy, while the total flux of the point source is 37 mJy.

A third run was performed on April 23 2001, i.e., one day later. The obtained map shows a point-like source with a flux density of 65 mJy. This increase in flux density from the second to the third run could be due to a mini-outburst or to the onset of the major outburst. In any case, the jet-like structure is not detected in the obtained map. The expected evolution of the flux density of an adiabatically expanding cloud in the optically-thin regime is $S \propto t^{-4.8}$ (van der Laan 1966; Mirabel & Rodríguez 1999). This implies a flux density of the jet components below the 3σ level of the map. This point will be further discussed in Massi et al. (2002, in preparation).

The last run, carried out on May 3 2001, corresponded to a radio phase of 0.15, therefore outside the "active window". The source was unresolved and its flux density was 25 mJy, typical of the "quiescent" regime.

4. Conclusions

LS I +61 303 has been observed several times with VLBI. However, the complex morphology at mas scales always prevented a clear interpretation of this source in the context of microquasars. The EVN observations by Massi et al. (2001), sampling larger structures, showed for the first time some evidence of a jet. The MERLIN observations reported here, at much larger scales, have allowed us to clearly confirm the existence of a jet in the high mass X-ray binary LS I +61 303, pointing towards a microquasar nature for this source.

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