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VSOP observations of the X-ray binary LSI +61°303

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Abstract. We have made multi-epoch observations of the unusual X-ray binary star LSI +61°303 using the HALCA spacecraft in combination with a large array of ground radio telescopes. We present initial analysis of six observing epochs during a radio outburst. The images reveal an apparently stationary pattern of symmetric emission extending about 2 mas on either side of a central source. The central source is observed to expand at a rate of 0.25 mas/day. At the distance to LSI +61°303, this corresponds to $\sim$ 860 km/s.

1. Background

LSI +61°303 undergoes nonthermal radio outbursts every 26.5 days, that rise from quiescence to peak flux within 48 hours. These are attributed to the eccentric orbit of a gravitationally collapsed object orbiting within the dense circumstellar envelope of a B0e star. In addition, the relative gamma-ray to X-ray luminosity of the system is far higher than in any other known X-ray binary system, indicating a fundamentally different energy production mechanism.

Previous VLBI observations near peak flux density a few days after the onset of an outburst indicate a very compact source $\sim$ 1 mas in size, suggesting a low rate of expansion of a few hundred km/s. Observations at quiescence reveal a radio source with dimensions of $\sim$ 4 mas. In contrast, observations of a small flare following a major outburst indicate initial expansion velocities of order $\sim$ 18 000 km/s, with deceleration upon reaching dimensions of $\sim$ 2 mas. A clear picture of the evolving radio emission, linking these diverse results, remains elusive.

2. Observations and Analysis

LSI +61°303 was observed at 5GHz with the HALCA orbiting antenna of the Japanese-led VSOP mission, and a ground array of 18 radio antennas including the European VLBI Network, the NRAO Very Long Baseline Array, and the VLA. Observations were obtained for 48 hours, beginning 00:59 on 16 September 1999. Unfortunately, the global-VLBI session started 60 hours after the onset of a radio outburst, by which time the flux had already climbed to a peak value

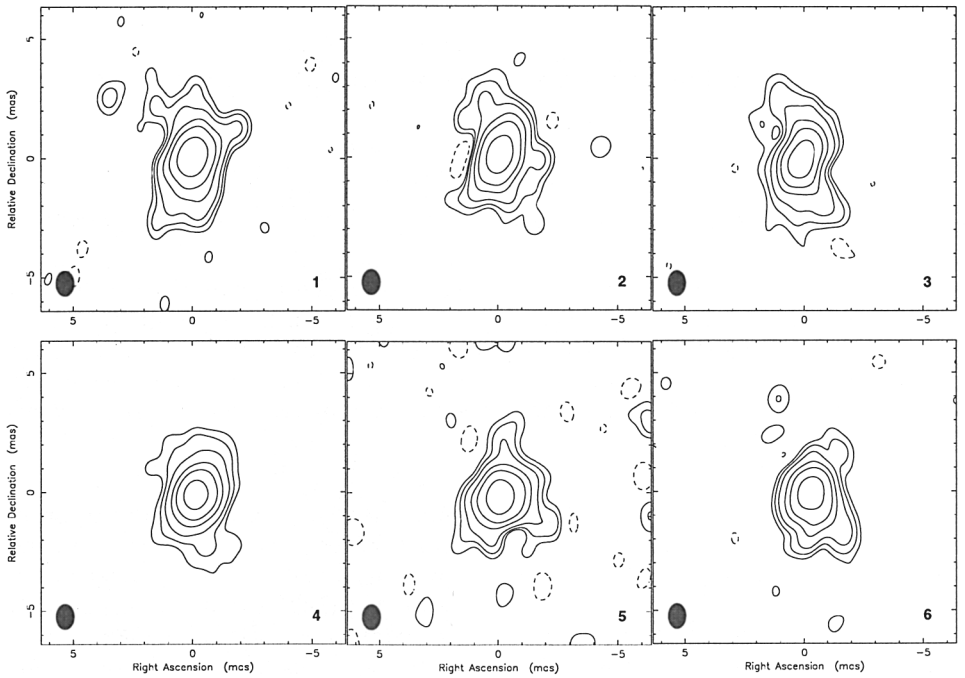

Figure 1. Images from six epochs during the outburst. The restoring beam is shown in the lower left-hand corner of the images.

$\sim$ 190 mJy. However, the flux of the source measured by the phased-VLA during the VLBI observations shows considerable variation after the initial climb to the peak flux value.

Initial images have been constructed from six epochs (figure 1). All images show a central resolved source and quasi-symmetric extensions toward the north-east and south-west (except the last two epochs), out to a radius of $\sim$ 2 mas. The maximum extent appears similar in all images. However, the central resolved source changes in size over the course of the observation. In particular, during the first three epochs it is similar in extent, but grows in the north-east/south-west direction by the fourth epoch. During the last three epochs, it changes little. The change in angular extent of the central source allows, for the first time, a direct measure of the expansion rate of the outburst ejecta of LSI +61°303. Between epochs 3 and 4, the minor axis of the fitted Gaussian expands by 50% from 0.52 to 0.77 mas, corresponding to a change of 0.5 AU at the 2.0 kpc distance to LSI +61°303. The inferred expansion velocity is 860 km/s, in the direction of the extended lobes. The overall size of the radio emission is about 4 mas. The radio extensions may represent a) a quasi-steady state emission region that is continually replenished in energetic particles by the recurring outbursts, or b) a high velocity component of the outburst ejecta that rapidly expands to radii of 2 mas and then decelerates. Our analysis is at a very preliminary stage and a number of issues remain unclear. However, we hope to address these in the near future.

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