Orbital and superorbital variability of LS I +61 303 at low radio frequencies with GMRT and LOFAR

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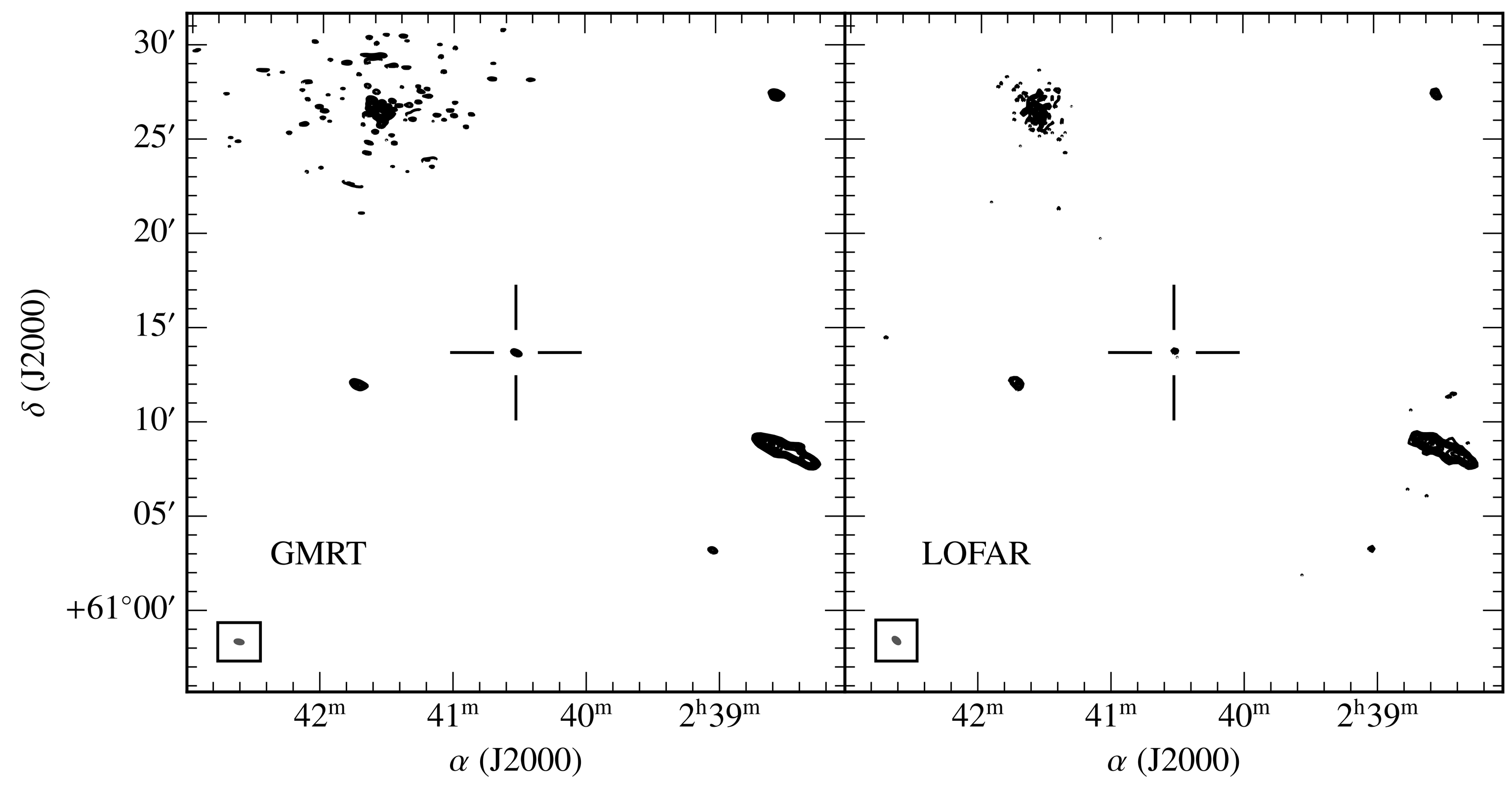
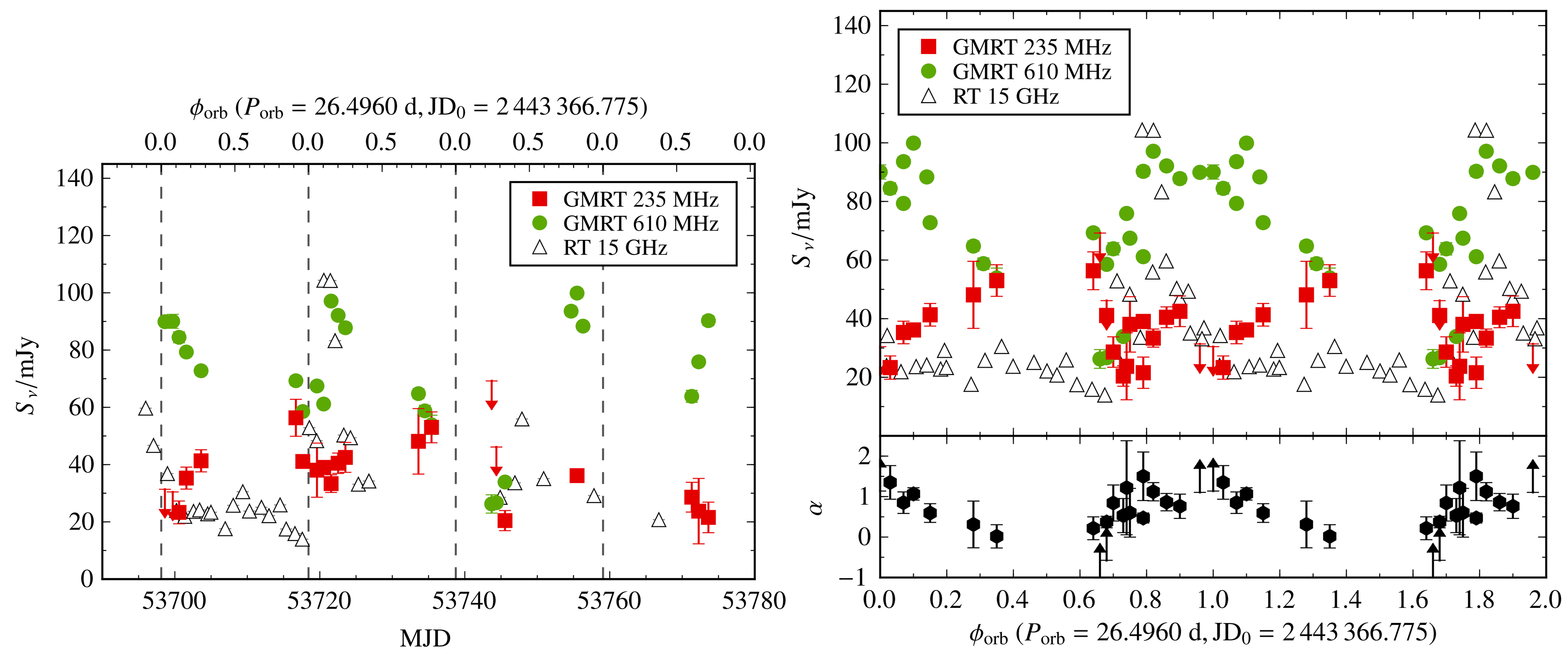
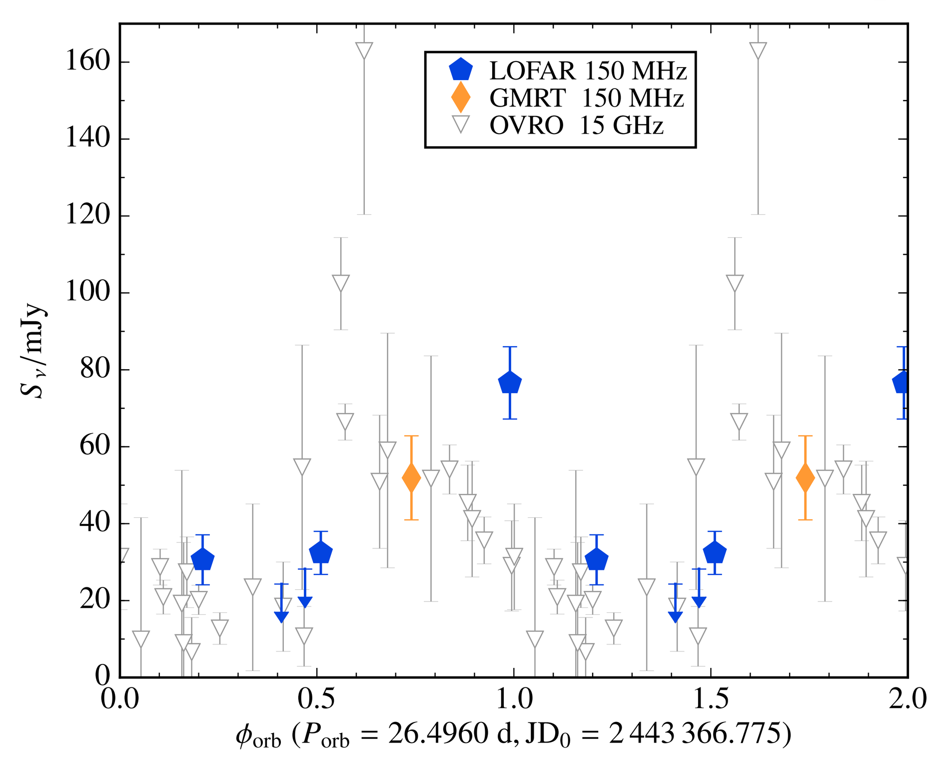
LS I +61 303 is a gamma-ray binary that exhibits an outburst at GHz frequencies each orbital cycle of 26.5 d and a superorbital modulation with a period of 4.6 yr. We have performed a detailed study of the low-frequency radio emission of LS I +61 303 by analysing all the archival GMRT data at 150, 235 and 610 MHz, and conducting regular LOFAR observations within the Radio Sky Monitor (RSM) at 150 MHz. We have detected the source for the first time at 150 MHz, which is also the first detection of a gamma-ray binary at such a low frequency. We have obtained the light-curves of the source at 150, 235 and 610 MHz, all of them showing orbital modulation. The light-curves at 235 and 610 MHz also show the existence of superorbital variability. A comparison with contemporaneous 15-GHz data shows remarkable differences with these light-curves. At 15 GHz we see clear outbursts, whereas at low frequencies we see variability with wide maxima. The light-curve at 235 MHz seems to be anticorrelated with the one at 610 MHz, implying a shift of ~0.5 orbital phases in the maxima. We model the shifts between the maxima at different frequencies as due to changes in the physical parameters of the emitting region assuming either free-free absorption or synchrotron self-absorption, obtaining expansion velocities for this region close to the stellar wind velocity with both mechanisms. The inferred values would give further support to the young non-accreting pulsar wind scenario. All these results are published in Marcote et al. (2015, submitted).



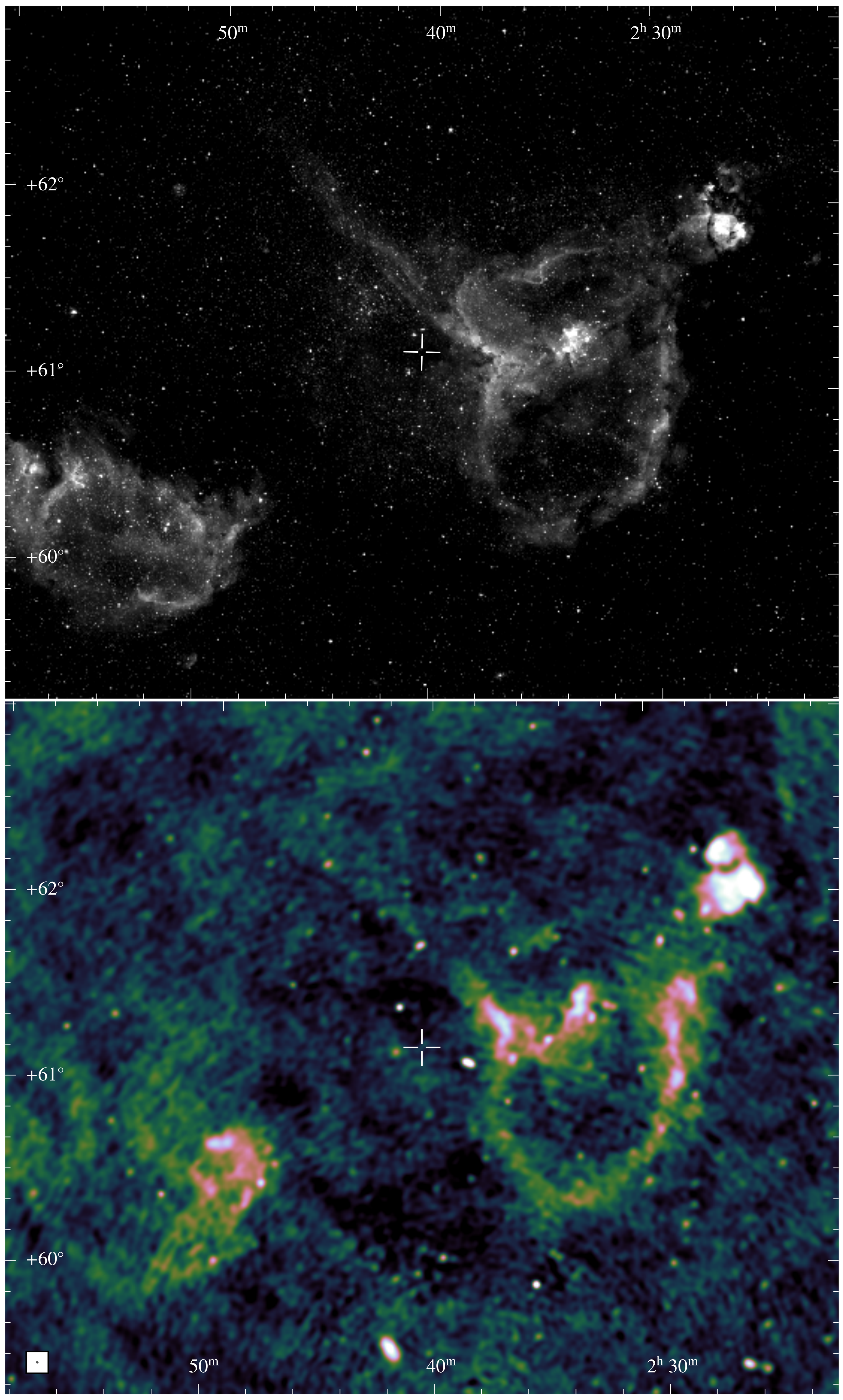
Detection of LS I +61 303 in the 2008 Feb 18 154-MHz GMRT observation (left) and in the 2013 July 14 149-MHz LOFAR observation after removing baselines below 0.2 kλ (right).



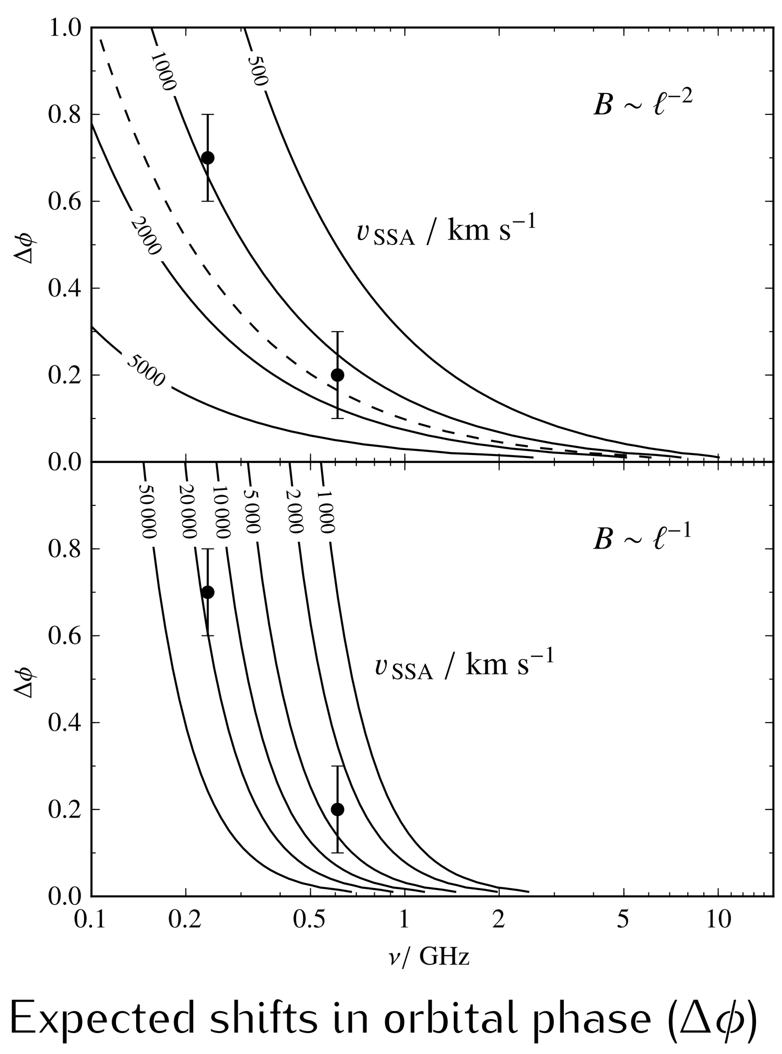
Flux density values of LS I +61 303 as a function of the MJD (left) and folded with the orbital period (right) from the analyzed GMRT and RT data. The black data (left bottom) shows the spectral index in the range of 235–610 MHz. We observe an orbital modulated light-curve. The 610-MHz data shows a quasi-sinusoidal modulation with a slower decay with respect to the 15-GHz data. The 235-MHz light-curve is almost anticorrelated with the one observed at 610 MHz.

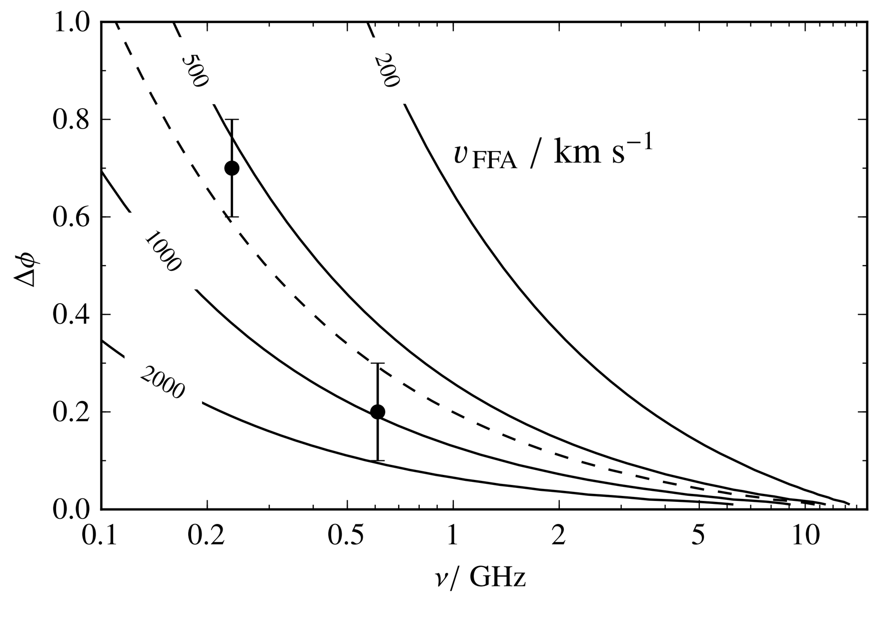


Folded light-curve of LS I +61 303 with the orbital period from the 150-MHz data. We observe an orbitally modulated emission, with the outburst slightly delayed with respect to the contemporaneous 15-GHz data. We note that these 150-MHz observations were taken at different superorbital phase ($\phi_{so} \sim 0.8$) compared to the ones at 235 and 610 MHz (0.2). Therefore we can not directly compare the behavior of the source from these two data sets.

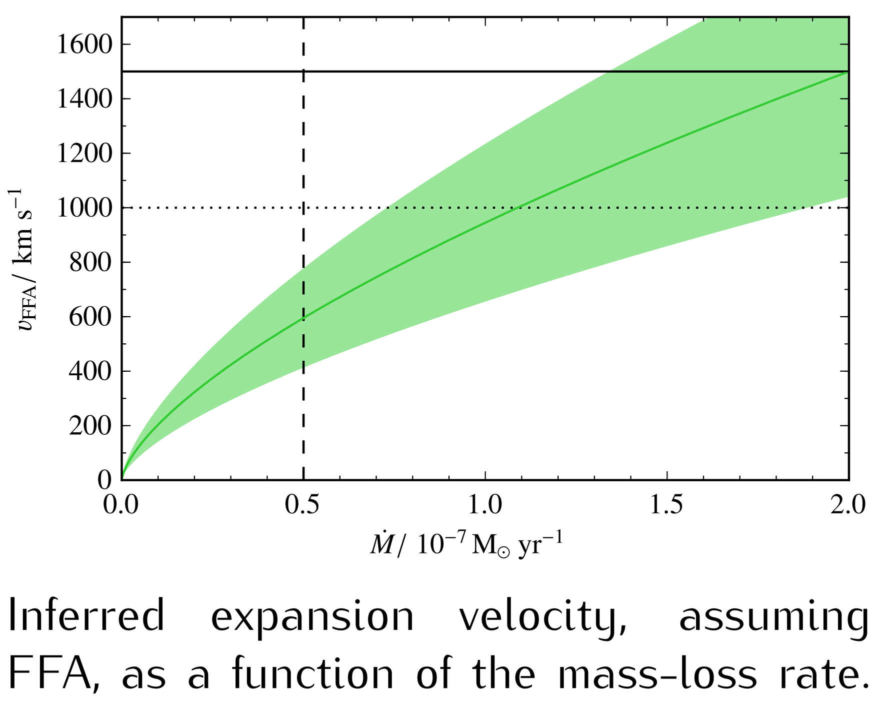


Field of LS I +61 303 seen by POSS II (Reid et al. 1991) at optical red F band (top), and by LOFAR at 149 MHz on 2013 July 14 (bottom).





Expected shifts in orbital phase ($\Delta\phi$) for the maxima in the flux density emission between a frequency ν and 15 GHz for different velocities of expansion of the radio emitting region considering synchrotron self-absorption with different dependences of the magnetic field with the size of the emitting region (v_{SSA}, top figures) or free-free absorption (v_{FFA}, top right column).



Inferred expansion velocity, assuming FFA, as a function of the mass-loss rate. The vertical dashed line denotes the expected mass-loss rate. We compare the obtained velocities with the mean stellar wind velocity (solid line) and its lower expected value (dotted line).