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Radio and X-ray variability of LSI+$61^0$303

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Abstract. We tested the ejector-propeller (E-P) model of the Be/X-ray binary LSI+$61^0$303 by using the parameters predicted by the model in the calculations of the X-ray and radio variability. The results are: (1) in terms of the E-P model, the X-ray maximum is due to the periastron passage; (2) the radio outburst can be really a result of the transition from the propeller to the ejector regimes; (3) the radio outburst will delay with respect to the X-ray maximum every orbital period. The proposed scenario seems to be in good agreement with the observations.

Key words. stars: individual: LSI+$61^0$303 – X-rays: stars

LS I+61°303 is a Be/X-ray binary with radio outbursts every 26.5 d, assumed to be the orbital period. After the discovery of the radio variability (Gregory & Taylor 1978) and the first model (Maraschi & Treves 1981), this massive system has been studied extensively. The source is also variable in X-rays (Goldoni & Mereghetti 1995; Leahy 2001). On two occasions, the LS I+61°303 flaring events have been monitored by radio facilities and X-ray satellites in a coordinated way (Taylor et al. 1996; Harrison et al. 2000). In both cases the radio peak is delayed with respect to the X-ray maximum. The flaring radio emission of LS I+61°303 has been modeled by Paredes et al. (1991) as synchrotron radiation from an expanding plasmon containing relativistic particles and magnetic fields.

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The genesis of such plasmon can be a result of transition of the neutron star from propeller (P) to the Ejector (E) regime. In the terms of E-P model we can put constrains on the allowed ranges for the most important parameters. Using the parameters appropriate for the E-P model and the plasmon prescription we generated radio and X-ray light curves. The variability calculated in terms of the E-P model is similar to the observed. The radio outbursts peak can be achieved 2-8 days after the appearance of the plasmon. The appearance of the plasmon can be expected when the neutron star emerges from the denser part of the disk, i.e. 2−5 days after the periastron. In the calculated curves the X-ray maximum corresponds to the periastron. The switch on of the ejector will be $0.1-0.4\,P_{orb}$ later. It means that the radio peak will delay with 3-13 days after the X-ray maximum. This is the behavior observed in both cases of the simultaneous radio and X-ray observations.

(1) Radio maps: High resolution radio maps have evidenced one sided radio jet at milliarcsecond scales (Massi et al. 2001). These authors interpret it as a microquasar bipolar ejection with significant Doppler boosting effect. The E-P model, provides however an alternative interpretation and this paper is devoted to the exercise of assessing it. Considering that the plasmon will be formed on one side of the Be star (the apastron vicinity), one sided radio jet is naturally expected. *(2) Asymmetry of the cavern:* To model the radio light curves we assumed that the plasmon expansion is spherically symmetric. But in the real case this region will be non symmetric. Moreover different forms of the cavern are possible, for more details see Lipunov & Prokhorov (1984). In addition, the fact that the neutron star ejects relativistic particles at the apastron of an eccentric orbit will lead to a radio source which is elongated in the direction of apastron. In any case, the radio source formed around the ejecting neutron star will be elongated in direction controversial to the direction to the B star. *(3) Strong and weak radio outbursts:* It was discovered that radio outburst peak flux density varies over a time scale of 1600 days. On the same time scale the Hα emission of the outflowing disk (Zamanov & Marti 2000) varies as well, and may be even the X-ray maximum (Apparao 2001). Our preliminary tests evidenced that a slower expansion velocity and stronger magnetic field give higher radio peak flux densities and the outburst peaks later. Also a faster expansion velocity and lower magnetic field will result into lower peak flux densities and the earlier outburst peaks. *(4) Multiple Outbursts:* A mechanism of multiple formation of caverns around an ejecting neutron star is proposed (Lipunov & Prokhorov 1984). We can speculate that, in case of multiple peaks in the LS I+61°303 radio outbursts, we may be observing such a multiple cavern formation. Another possibility is a density structure in the wind of the Be star, i.e. rings with higher density that can change the regime more than once during one orbital period. *Other possibilities:* An alternative of the proposed model is the transition closed-open cavern around the ejecting neutron star. It can not be excluded that a magnetized black hole is acting in LS I+61°303 (Punsly 1999). If such a compact object does exist in LS I+61°303, the microquasar scenario proposed by Massi et al. (2001) should be also considered seriously. Further observations are required in order to finally solve the true nature of this X-ray binary. High resolution maps could help us to understand the birth and the initial expansion of the plasmon.

The main results are: (1) the parameters expected from the E-P model are appropriate for the radio plasmon and the simulated radio light curves are similar to the observed; (2) in terms of E-P model the X-ray maximum is a result of the propeller action during the periastron passage of the neutron star; (3) the periastron is expected to correspond with radio phase ~ 0.5 using the late radio ephemeris - i.e. the time of the X-ray maximum; (4) the observed phase shift between the radio and the X-ray maxima is in agreement with our model of LS I+61°303. We expect that the X-ray and the radio maxima will always peak at different orbital phase.

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