PROBABLE EVOLUTION OF LSI+61°303

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LSI+61°303 (GT 0236+610) is a radio-emitting X-ray binary which exhibits periodic radio outbursts. The main component in the system is a main-sequence B0 star and the secondary is most probably a neutron star (for details see ref. 1 and references therein).

Here I discuss the possible evolution of the neutron-star spin period in this binary in the light of the ejector-propeller model[2]. In this model it is supposed that, as a result of the eccentric orbit, the type of interaction between the neutron star and the wind of primary is variable: a propeller régime at periastron and an ejector régime close to apastron. Radio eruptions are due to the transition from propeller to ejector stages, and the appearance of a relativistic wind during the ejector stage.

As a result of spin-down, a neutron star in a binary system will go through different stages[3,4,5]. The spin-down moment can be estimated as[6]

$$K_{Sd} = \begin{cases} \dfrac{\mu^2}{3R_M^3} & \text{during the propeller stage} \\ \\ \dfrac{2\mu^2}{3R_L^3} & \text{during the ejector stage} \end{cases} \qquad (1)$$

Here μ is the magnetic dipole moment of the neutron star, for which we adopt $\mu = 2 \times 10^{30}$ G cm^3, R_L is the light-cylinder radius, and R_M is the Alfvén radius,[4]

$$R_M = \left[\frac{\mu^2}{\dot{M}\sqrt{2GM}}\right]^{2/7} \qquad (2)$$

where M is the mass of the neutron star, for which we adopt $1 \cdot 4 M_\odot$, and $\dot{M}$ is the mass capture rate, which is variable along the orbit between the limits[2] $(5\text{–}50) \times 10^{-10}\ M_\odot$ yr^{-1}.

Considering that the neutron star in LSI+61°303 is in the propeller régime between radio phases 0·05–0·55 and the ejector regime at other times, the average spin-down moment will be $K_{Sd} \simeq 1 \cdot 3 \times 10^{34}$ dyne cm. The spin-down moment is connected with the evolution of the spin period:

$$\frac{dI\omega}{dt} = K_{Sd} \qquad (3)$$

where I is the rotational moment of the neutron star, for which we adopt $I = 10^{45}$ g cm^2, and ω is the angular velocity.

It has been calculated[2] that for the ejector–propeller transition it is necessary for the spin period of the neutron star in LSI+61°303 to be in the range 0·15–0·20 s. This leads to an estimate that the stage during which the neutron star can show periodic radio outbursts caused by a propeller–ejector transition can be as long as 2×10^4 yr.

When the neutron-star period increases up to 0·2 s, periodic radio outbursts from LSI+61°303 will stop; the neutron star will be in a propeller régime for the whole binary period. An X-ray luminosity of order 10^{33}–10^{34} erg s^{-1} or lower will be generated during this stage, and the deceleration of rotation will continue. When the spin period increases sufficiently, accretion will begin. The period at which accretion will be possible can be estimated as[4]

$$P \geqslant \frac{2\pi}{\sqrt{GM}} \left[\frac{\mu^2}{\dot{M}_c \sqrt{2GM}} \right]^{3/7} \tag{4}$$

This corresponds to 2·8 s for a mass capture rate of $5 \times 10^{-9} M_\odot \text{ yr}^{-1}$. Using Eqns. 1 and 2, the time necessary for spin-down from 0·2 to 2·8s is of the order of 7×10^4 yr. When the accretion begins, X-ray pulses will appear, and the X-ray luminosity will increase up to $(4–50) \times 10^{36}$ erg s^{-1}. The star will be similar to the X-ray pulsars where the main component is a Be star[7], such as 4U0115+63, V0332+53.

To conclude, we can say that, if the above considerations are true, after $\lesssim 10^5$yr LSI+61°303 will belong to the group of X-ray pulsars, which has now more than 30 members.

References

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SPECTROSCOPIC BINARY ORBITS FROM PHOTOELECTRIC RADIAL VELOCITIES

PAPER 125: HD 99903

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HD 99903 is shown to be a double-lined system with a 61-day orbit of modest eccentricity. The other astrophysical data on it, consisting only of its HD spectral type of K0 and its magnitudes on the 'International' system, are consonant with its being a main-sequence pair, as is also suggested by its non-zero eccentricity and the undetectably small rotation of both components. The masses of the individual components are, however, considerably in excess of 1 $M_\odot$ and furthermore they are very similar to one another despite the substantial disparity in the depths of the two dips on radial-velocity traces. It therefore seems inescapable that the system consists of a pair of evolved stars, but the writer cannot explain why tidal effects have neither circularized the orbit nor synchronized the rotations of the stars with the orbital period. Spectroscopic and photometric observations are evidently very desirable.