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ON THE ORBITAL ECCENTRICITY CHANGES IN MAGNETIC CLOSE BINARY SYSTEMS

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ABSTRACT. *The model of Joss et al. (1979) is generalized to the case of the eccentric orbits in magnetic binaries. The trial eccentricity increases, if the rotational axis of the white dwarf and that of the orbital motion coincide, or the angle between them is less than* 90° *, and decreases in the opposite case. The characteristic times of such process are* $(1 - 5) \cdot 10^{9}$ *yrs* for *the "near-synchronous" rotation of the white dwarf, and* $(1 - 4) \cdot 10^{8}$ *yrs for the "rapidly rotating" white dwarf with the characteristic period of* 71^{s}*, for the adopted parameters of the "long-period" and "short-period" polars.*

The presence of the magnetic field of the white dwarf (WD) in cataclysmic variables (CV) affects not only the structure of the accretion flow, but the motion of the stellar components as well. Joss et al. (1979) have shown, that the ohmic dissipation of the Faukot currents in the secondary's envelope may lead to synchronization of the orbital and rotational motion of the WD. Andronov (1982, 1987ab) showed that the plasma ejection at the "propeller stage" is much more efficient mechanism for synchronization with characteristic time $t_s \le 10^{3}$ yrs. However, the model of Joss et al. (1979) may be extended to the case of eccentric orbits (cf. Andronov, 1983), and here we present the estimates of the characteristics of such a process. To study the secular eccentricity changes, we used the evolutionary expression

$$\frac{de}{dt} = \frac{(1-e^2)^{1/2}}{2\pi a} \int_0^P (S \sin E + T \cos v)\, dt,$$

where P - is the orbital period, $\omega = 2\pi/P$ - the corresponding angular frequency, a - the large semi-axis of the orbit, v and E - the true and eccentric anomalies, respectively, S and T - the radial and tangential parts of the disturbing acceleration. Introducing the "effective drag force", one may obtain

$$S = A \frac{e\sin E}{(1+e\cos E)(1-e\cos E)^6},$$

$$T = A \frac{(1-e^2)^{1/2}}{(1+e\cos E)(1-e\cos ER)^6}$$

(Andronov, 1983), where, taking into account the dissipative losses (Joss et al., 1979),

$$A = \frac{15c}{8} \frac{M_1 + M_2}{M_1 + M_2} \left(\frac{\zeta}{2\pi\sigma}\right)^{1/2} \frac{N^2R_2^2}{\omega a^7} \sin^2\gamma.$$

Here c is the light speed, ζ - the angular velocity of the WD rotation in respect to the rotating binary system, σ - the conductivity of the secondary's envelope, N - the magnetic moment of the dipole, R - the effective radius of the secondary, γ - the angle between the magnetic axis and the rotational axis of WD. It is assumed that the latter is parallel to the rotational axis of the orbital motion. Taking into account only the first term of the series expansion on eccentricity e, one may obtain

$$\frac{de}{dt} = \pm \frac{1}{\tau_e} e,$$

where $\tau_e = \omega a/5A$. The positive sign is to be taken if the rotational and orbital axes are of the same orientation.

For the numerical estimates, we will use the "mass-radius" relation tor the white dwarfs (Dibay and Kaplan, 1976) $R_1 = 8.82\cdot 10^8 \ (M_{wd}/M_\odot)^{-1/3}$ cm. The secondary's radius $R_2/a = 0.462\ \mu^{1/3}$, where $\mu = M_2/M$, $M = M_1 + M_2$ (Paczynski, 1971), thus

$$\tau_e = 5.62\cdot 10^7\ T^{3/4}P^2P_s^{1/2}\ B_8^{-2}\ (M_1/M_o)^5\mu^{2/3}(1-\mu)^3(\sin\gamma)^{-2}\ yrs.$$

Here the orbital period P is expressed in days, $P_s = 2\pi/\zeta$ - in seconds, the magnetic field strength at the magnetic pole B - in units of 10^8 Gs.

The characteristic times of the orbital eccentricity changes τ_e and of the synchronization τ_s for the two polars at the opposite parts of the "period gap" are presented in Table 1.

For the "short-period" systems, the secondary's temperature is usually smaller, as well as the total mass. Thus, the values of τ_e and τ_s may be some times smaller. The large semi-axis of the orbital motion is changing with the characteristic time

$$a/(da/dt) = 2.5\ \tau_e,$$

corresponding to the conservation of the total moment of impulse.

The proposed mechanism is less effective, as compared with the tidal interaction, and is compared with the influence of the gravitational radiation (Landau and Lifshitz, 1973).

Table 1. Estimates of the characteristic times τ_e and τ_s for the "long-period" (AM Her) and "short-period" (AN UMa) polars

Star	P(s)	P_s(s)	τ_e(yrs)	τ_s(yrs)
AM Her	$1.11\cdot10^4$	$1.11\cdot10^4$	$4.8\cdot10^9$	$5.8\cdot10^7$
		71	$3.8\cdot10^8$	$7.1\cdot10^{10}$
AN UMa	$6.89\cdot10^3$	$6.89\cdot10^3$	$1.4\cdot10^9$	$3.3\cdot10^7$
		71	$1.5\cdot10^8$	$2.0\cdot10^{10}$

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