SIMULATIONS OF ANGULAR MOMENTUM EVOLUTION IN WIND-FED CV PRECURSORS

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1. Introduction

It is thought that the secondary stars in cataclysmic variables (CVs) may undergo a period of mass loss in the form of a wind during the evolution of the system (Mullan et al. 1992). This wind is thought to magnetically brake the secondary star with a time-scale $\sim 10^8$ yr (e.g. van Paradijs 1986). When the secondary's spin has been brought close to synchronism with the orbit it is possible for tidal torques to lock the secondary in synchronous rotation.

We have modelled this process by adapting a method that has proved successful in explaining the properties of the intermediate polars (Wynn & King 1995). We model the secondary magnetic field as a pure dipole which drags on the wind material as it crosses field lines. This has the effect of trying to force material to move along field lines. This does not model the magnetic interaction completely since it does not allow for the back reaction of the material on the field structure. However, this will only become significant in regions where the field is weak and hence where material is not exerting a large torque on the star.

We can compare our results to previous calculations to enable us to calibrate the strength of the drag term in the equations of motion. Future work will involve extending this treatment to the white dwarf (WD) in such systems to examine the effect of the wind material on the WD spin.

2. The simulation

The simulations were carried out with an adapted version of HYDISC (Whitehurst 1988a,b). We simulated the effect of the magnetic field by a drag force per unit mass:

$$\mathbf{f}_{\rm drag} = -k[\mathbf{v}' - (\mathbf{v}'.\mathbf{b})\mathbf{b}] \tag{1}$$

A. Evans and J. H. Wood (eds.), Cataclysmic Variables and Related Objects, 443–444.

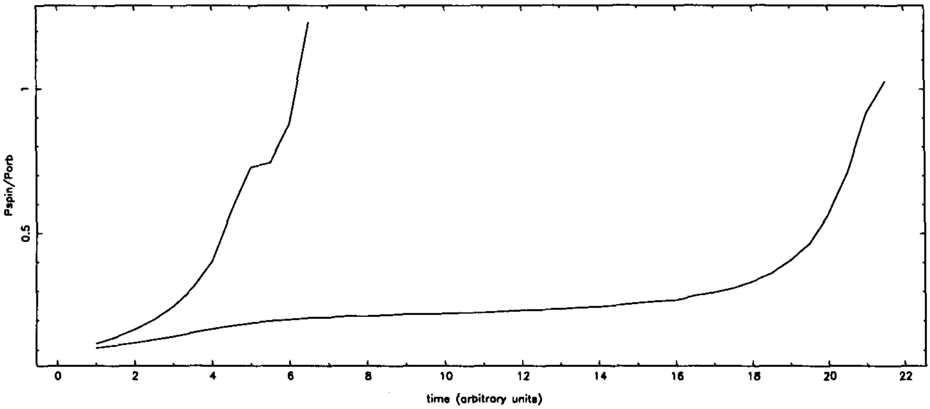

Figure 1. Graph of P_{spin}/P_{orb} for two evolutions with $k = 1.40\ s^{-1}$ (faster) and $k = 0.140\ s^{-1}$.

where $\mathbf{v}'$ is the velocity of the particle relative to the (rotating) field and $\mathbf{b}$ is a unit vector in the local field direction. The parameter k is the strength of the drag effect. In general it will be related to the magnetic field strength at any point.

3. Results

We followed a scheme where the gravitational attraction of the secondary was assumed everywhere to be balanced by the mechanism causing the wind mass loss. The wind was ejected initially from the surface of the secondary which was assumed to be spherical with a radius inside the Roche lobe. The orbital period was 8 h. Fig. 1 shows the effect on the secondary spin of two different values of k. The pole of the dipole was taken to be in the plane of the orbit for both of these simulations. The initial speed of the material was $10\,c_s$. The time to evolve P_{spin}/P_{orb} from 0.1 to 1 was $\sim 2\,10^8$ yr for the faster (high field) evolution, assuming a mass loss rate of $\sim 10^{-10}\ M_\odot\ yr^{-1}$.

References

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