INNER EDGE DRAG BY AN ASYNCHRONOUS PRIMARY AND ACCRETION DISC STRUCTURE IN CLOSE BINARIES

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1. Model and results

In this work a 3–D 'Smoothed Particle Hydrodynamics' ([1]; [4]; [5]) accretion disc is simulated where particles at its inner edge are dragged by a fast spinning compact central star, as in the case of the intermediate polars. The angular velocity of the central star is twice the orbital angular velocity ω_o. This drag can be attributed mainly to viscous interaction in the dense compact star atmosphere, although magnetic coupling may also play a role.

Our simulations have been performed for a system with a primary (a white dwarf) mass $M_1 = 1.3\,\mathrm{M}_\odot$, a secondary mass $M_2 = 2.2\,\mathrm{M}_\odot$, a separation between the components (centre to centre) $d_{12} = 6.33\,10^{11}\,\mathrm{cm}$ and an orbital period $= 1.7\,\mathrm{d}$, the integration time being as long as $\simeq 75\,\mathrm{d}$. As in [2] and [3], we have considered quasi-polytropic structures with $\gamma = 1.01$. We adopt the term quasi-polytropic since we have in fact solved also an energy equation.

The results of our simulations indicate that the drag due to a fast spinning compact primary has a fundamental influence on accretion disc formation, structure, dynamics and energetics, in a way largely different from the co-rotation case. The disc mass becomes stationary after about 25 orbital periods.

In Fig. 1 four XY plots (orbital plane) of the accretion disc are shown for four different times: $t = 268, 270, 273$ and 275, where the time is measured in units of $P_{\mathrm{orb}}/2\pi$. The corresponding numbers of particles are: $N = 10\,137, 10\,182, 10\,169, 10\,138$. At all these times the disc seems to be surrounded by an expanding cloud of hot particles, released by its outer

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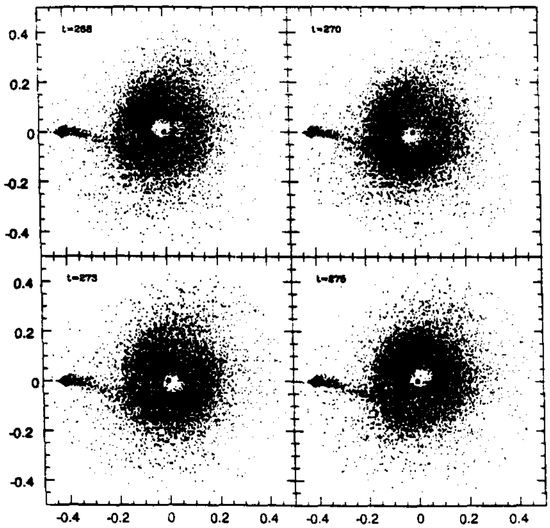

Figure 1. XY plots of the accretion disc at $t = 268$, 270, 273 and 275 (see text).

edge and interpretable as an anisotropic hot wind. The most evident characteristic of the disc dynamical evolution is an inner edge asymmetric azimuthal oscillation with a frequency equal to ω_o, as the four XY plots of Fig. 1 clearly show. Therefore, the centre of the inner edge of the accretion disc and the centre of the compact star, which is also the centre of the rotating frame, do not coincide. This oscillation produces a particle compression wave, localized in inner edge regions closer to the primary, which causes a local thickening of the disc itself in regions more distant from the primary. In other words, during the disc rotation, particles at the inner edge, being at a certain time closer to the primary, are scattered toward the opposite side of the edge by a 'sling' effect due to the rotational drag. Owing to collisions among particles, this results in a local bump in the disc thickness, with an azimuthal shift of about 180° and at an increased distance from the primary.

The radial temperature distribution shows a disc heating up and a flat profile as a consequence of the additional energy source provided by the rotational drag, which is converted into heat owing to the high collisional rate among particles.

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