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DISK STRUCTURE AND EVOLUTION AROUND THE NEUTRON STAR IN BE/X-RAY BINARIES

Kimitake Hayasaki[1] and Atsuo T. Okazaki[2]

We investigate the accretion flow around the neutron star in Be/X-ray binaries, using a 3D SPH code and the data imported from simulations by Okazaki et al. (2002) and Okazaki & Hayasaki (2004) for both a coplanar system and a misaligned system in which the Be-star disk is inclined from the binary orbital plane by 30 degrees, with a short period (P_{orb} = 24.3 days) and moderate eccentricity (e = 0.34). We find that a non-steady accretion disk is formed around the neutron star in the misaligned case as well as in the coplanar case. The disk size in the misaligned system is significantly larger because of its higher angular momentum than that in the coplanar system. We also find that the disk also evolves via a two-stage process, which consists of the initial developing stage and the latar developed stage.

The Be/X-ray binaries represent the largest subclass of HMXBs. These systems consist of a neutron star and a Be star with a cool equatorial disk. Most of the Be/X-ray binaries show only transient outbursts in the X-ray emission. These outbursts result from the transient accretion onto the neutron star from the Be-star disk. In this paper, we perform numerical simulations of accretion flow around the neutron star in Be/X-ray binaries, using the 3D SPH code (Bate et al. 1995) and the mass-transfer rate from the Be disk obtained by Okazaki et al. (2002) and Okazaki & Hayasaki (2004).

In Be/X-ray binaries, it is probable that the Be disk is inclined from the binary orbital plane. According to Okazaki & Hayasaki. (2004), the inclination angle significantly depends on the mass-transfer rate. In highly inclined systems, the mass-transfer rate shows the double peaks per orbit, unlike a single-peaked profile in coplanar systems. Figure 1 shows snapshots of the accretion flow around the neutron star at periastron of the seventh orbital period and evolution of the disk size for $0 \lesssim t/P_{orb} \lesssim 8$.

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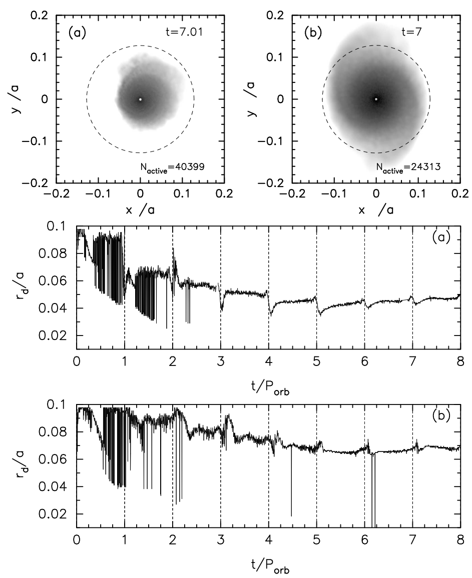

Fig. 1. Snapshots of the developed disc at t=7 (the upper panels) and evolution of the disk radius for $0 \lesssim t/P_{orb} \lesssim 8$ in the coplaner case (a) and the misaligned case (b). The upper panels show the surface density in the logarithmic scale, projected on the plane vertical to the angular momentum axis of the disk. The dashed circle denotes the effective Roche lobe of the neutron star. Annotated at bottom-right corner of each panel are the number of SPH particles, N_{SPH}. In the middle and lower panels, the disk size r_d is normalized by the semi-major axis $a = 6.6 \times 10^{-12}$ cm.

It is noticed from the figure that the disk size in the misaligned case is significantly larger than that in the coplanar case through the process of evolution, since the angular momentum of the material transferred from the Be disk is higher than that of the coplanar case. We also notice that the disk in the misaligned system evolves via two-stage process as well as the coplanar case (Hayasaki & Okazaki. 2003).

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