The Lives and Death-Throes of Massive Stars
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Tidal tearing of circumstellar disks in Be/X-ray and gamma-ray binaries

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Abstract. About one half of high-mass X-ray binaries host a Be star [an OB star with a viscous *decretion* (slowly outflowing) disk]. These Be/X-ray binaries exhibit two types of X-ray outbursts (Stella *et al.* 1986), normal X-ray outbursts ($L_{\rm X}\sim10^{36-37}$ erg s^{-1}) and occasional giant X-ray outbursts ($L_{\rm X} > 10^{37}$ erg s^{-1}). The origin of giant X-ray outbursts is unknown. On the other hand, a half of gamma-ray binaries have a Be star as the optical counterpart. One of these systems [LS I +61 303 ($P_{\rm orb} = 26.5$ d)] shows the *superorbital* (1,667 d) modulation in radio through X-ray bands. No consensus has been obtained for its origin. In this paper, we study a possibility that both phenomena are caused by a long-term, cyclic evolution of a highly misaligned Be disk under the influence of a compact object, by performing 3D hydrodynamic simulations. We find that the Be disk cyclically evolves in mildly eccentric, short-period systems. Each cycle consists of the following stages:

1) As the Be disk grows with time, the initially circular disk becomes eccentric by the Kozai-Lidov mechanism.
2) At some point, the disk is tidally torn off near the base and starts precession.
3) Due to precession, a gap opens between the disk base and mass ejection region, which allows the formation of a new disk in the stellar equatorial plane (see Figure 1).
4) The newly formed disk finally replaces the precessing old disk.
Such a cyclic disk evolution has interesting implications for the long-term behavior of high energy emission in Be/X-ray and gamma-ray binaries.

Keywords. hydrodynamics; stars: emission-line, Be; X-rays: binaries

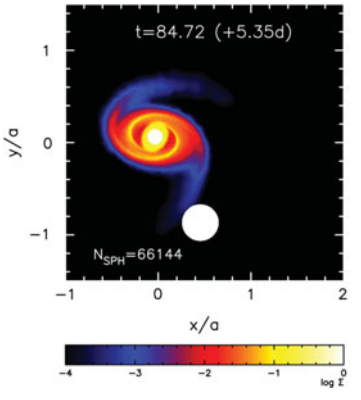

Figure 1. A snapshot from a simulation of the Be disk in the mildly-eccentric, short-period Be/X-ray binary 4U 0115+634. The disk consists of a precessing outer part and a newly formed inner part. The white filled circle denotes the Roche lobe radius of the neutron star.

Reference

Stella L., White N. E., Rosner R. 1986, ApJ, 208, 669