Tidal interaction in high-mass X-ray binary and symbiotic stars

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In this thesis the results of our investigations in the field of High-Mass X-ray binaries and Symbiotic stars on the basis of theory of synchronization and pseudosynchronization in close binary stars are presented. The High-Mass X-ray binaries contain a primary star of spectral type O or B and a compact object as a companion. The mass donors have a mass greater than $10M_{\odot}$. As a result of the accretion of matter from the primary, the compact object is a strong X-ray emitter and displays different types of activity. The High-Mass X-ray binaries are separated in two groups depending on the nature of the mass donor - High-Mass Supergiant and Giant Systems and Be/X-ray Binaries. Symbiotic stars are interacting binaries, consisting of an evolved giant (either a normal red giant in S-types or a Mira variable embedded in an optically thick dust shell in D-type) transferring mass to a white dwarf. The system is surrounded by a rich and luminous circumstellar environment resulting from the presence of both an evolved giant with a heavy mass loss and of a hot companion abundant in ionizing photons and often emanating its own wind.

We observed spectroscopically the galactic microquasar LSI+61 303 using the Coudé spectrograph of the 2-m RCC telescope at the Rozhen NAO. LSI+61 303 contains a compact object (probably a black hole) orbiting around a Be star in a highly eccentric orbit – e=0.537. On the basis of our observations, we concluded, that equivalent width (EW) of the Hα emission line varied from 8 to 14 Å. The separation between blue and red peaks of this line varied from 250 to 400 km/s. The 1667 day modulation reflects Hα parameters, even during the time of lower EW (Hα). Regarding our observations, orbital period of LSI+61 303 influenced EW(B)/EW(R), EW (Hα), FWHM (B), FWHM (R) and radial velocity of the dip between two peaks of Hα line. The 4-year modulation influenced only EW(B)/EW(R) and EW (Hα) (Zamanov, Stoyanov & Tomov 2007; Stoyanov et al. 2008).

The theory of tidal interaction in close binary stars has been analyzed in the works of Hut (1981), Zahn (1989) and Hurley, Tout & Pols (2002). In a binary with a circular orbit the rotational period of the primary, P_{rot}, reaches an equilibrium value at the orbital period, $P_{orb}=P_{rot}$. In a binary with an eccentric orbit, the equilibrium is reached at a value of P_{rot} which is less than P_{orb} and the difference is a function solely of the orbital eccentricity of the system e. In systems with eccentic orbits, the tidal force acts to synchronize the rotation of the mass donor with the motion of the compact object at the periastron – pseudosynchronous rotation. We investigated the tidal interaction in 13 High-Mass X-ray binaries with known orbital and stellar parameters. We found that the Be/X-ray binaries are far away from synchronization/pseudosynchronization. The tidal force acts as a decelerator of the rotation of the mass donors. The objects containing mass donors supergiants or giants are close to synchronization/pseudosynchronization (Stoyanov & Zamanov 2009).

MWC 560 is a symbiotic star with P_{orb}=5.3 yr. The most spectacular features of this object are the collimated ejections of matter with velocities up to ∼6000 km/s (Tomov et al. 1992). On the basis of the theory of tidal interaction in close binaries, we estimated the orbital eccentricity of the system $e=$ 0.68 - 0.82 (Zamanov et al. 2010). This result is in agreement with the observational evidences for long orbital periods symbiotic stars and the model that the observed photometric variability of MWC 560 is connected with high orbital eccentricity and Roche lobe overflow at periastron. We also calculated the time-scales for synchronization, circularization and complanarity of the orbit of MWC 560 - $\tau_{sync}=2.6\times10^4$ yr, $\tau_{circ}=3.1\times10^6$ yr and $\tau_{al}=2.7\times10^4$ yr.

CH Cyg is a symbiotic star that is composed of an M7 giant and an accreting white dwarf. The hot component undergoes irregular outbursts accompanied by fast, massive outflows and jets (Karovska et al. 2007). Observations of CH Cyg with the Kepler satellite and the 60-cm telescope of the Rozhen NAO reveal that the minute-time-scale optical flickering that CH Cyg typically produces has disappeared (Sokoloski et al. 2010). Our CCD observations from the 60-cm telescope during three nights in May 2010 did not show any flickering above 0.04 mag in U, B, and V-bands.

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