EVOLUTION OF MASSIVE CLOSE BINARIES*

(Abstract)

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(1) The great interest to the evolution of massive binary stars ($M_1 \gtrsim 10\ M_\odot$) is to a considerable degree stimulated by a close connection between their advanced evolution and the origin of a part of W-R stars and of X-ray sources.

(2) In the present communication the results of computations of evolution of primary components of close binary systems with masses 16 $M_\odot$, 32 $M_\odot$, 64 $M_\odot$ are presented. The mass exchange in systems under consideration starts after hydrogen exhaustion in the primary core. The Ledoux stability criterion is used for handling of semiconvection.

(3) in all those systems the mass exchange lasts some thousand years only. The mass of remnants of primaries M_f after mass exchange is related to their initial mass M_i by an approximate relation $M_f/M_\odot = 10^{-0.96}(M_i/M_\odot)^{1.4}$. Mass exchange stops when the surface is reached by layers with a hydrogen content $X \approx 0.2$. After detaching from the Roche lobe the primary remnant moves rapidly to the region of the HR-diagram occupied by Wolf-Rayet stars. The range of masses of the remnants 5–35 $M_\odot$, their radii 1–7 $R_\odot$ and effective temperatures 50000–80000 K fit well the range of the same parameters for hot compact cores of WR stars. In order to fit the theoretical periods of binaries with WR components to observations it is necessary to assume a considerable mass and angular momentum loss from the system. Mass loss always occurs in such a way that first a WR star of the nitrogen sequence is formed. But the position of layers enriched by carbon allows the star to evolve into a carbon WR star by means of mass loss with a rate 10^{-6}–$10^{-5}\ M_\odot\ \mathrm{yr}^{-1}$ during the time of He exhaustion in the core.

(4) In the course of further evolution in core carbon and oxygen burning stages it is possible for the star to fill the Roche lobe several times but the subsequent mass loss is small – only some tenth of a solar mass. It is possible to observe the star in those evolutionary stages only if the neutrino emission is absent.

(5) After the primary explodes as a supernova, the systems remain bound as always the less massive component explodes. If the explosion is spherically symmetric this system with a component – a neutron star or a 'black hole' receives velocity up to 100 km s^{-1}, high enough to bring the system to the distance up to 100 pc from the galactic plane before the second supernova explosion in the system. The accretion on the relativistic component may lead to X-ray emission. After the second component explodes as a supernova, the system, as a rule, disrupts, giving birth to two single neutron stars or 'black holes', which may appear as sources of radio of X-ray

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emission. The spatial distribution of pulsars along the Z-coordinate agrees well with the observed (Gunn and Ostriker, 1970).

Reference

Gunn, J. E. and Ostriker, J. P.: 1970, *Astrophys. J.* **160**, 979.