THE EVOLUTIONARY CONNECTION AMONG CLASSES OF CLOSE BINARIES

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ABSTRACT. The evolutionary connection of different types of close binaries is suggested. The early type contact systems are presented as one of the evolutionary stages of close binaries.

Key words: Contact early binaries (CE-stars), low-massive detached systems (DS), semidetached systems (SDS), KW-type systems (KW), similar KW (∼KW), period change.

The modern investigations of low-mass close binaries ($M_{1,2} = 1.5M_{\odot}$) point to evolutionary connection of their different classes. On the base of study of the close binaries is classification made by Svechnikov (1980).

Many works, studing individual close binaries, observed papers, devouted to total classes of close binaries, statistical researchs of Catalogues of binary stars, the study of position of components on the different diagrams give possibility in more detail to learn individual classes and to follow their mutualconnection.

More complete the idea of the connection of classes of close binaries (especially of low-mass systems) follows from the primary mass - large semiaxis diagram, which was considered by Svechnikov (1984) for the first time.

Also the significant interest presents the diagram of degrees of filling of Roche-lobes by the components of eclipsing binaries of different types (Karetnikov, 1989), which was made on the base of Svechnikov's (1986) Catalogue.

Svechnikov and Snezhko (1974) divided out the region without unevoled close binaries on the primary mass - large semiaxis diagram ($M_1 = 1 - 5M_{odot}$, $A = 7.9 - 10R_{odot}$). This region contained only semi-detached systems. Next investigations showed that contact binaries of the early spectral types are in prohibited region. Physical parameters of components of CE-stars point on evolutionary unhomogeneous of these systems. About half of CE-stars from prohibited region experienced role exchange, other half became contact systems on main sequence yet. One may suppouse, that exist next evolutionary chains, where CE-systems were missed with link;

$$\text{DS} \rightarrow \text{SDS} \rightarrow \text{CE} \rightarrow \text{KW},$$
$$\text{DS} \rightarrow \text{CE} \rightarrow \text{KW}, \quad \text{DS} \rightarrow \sim\text{KW} \rightarrow \text{KW}.$$

The transition from CE to KW demands prooves, because except angular momentum loss must be loss of mass. For CE-systems without role exchange mass ratio of the components is $q \leq 0.5$, the degree of filling of Roche-lobes of the components is 90-100% and more, degree of filling of Roche-lobe of the primary is equal or more of the same mean for secondary component.

Systems with role exchange have secondaries fill their Roche-lobes more than degree of filling of Roche-lobe of primary, mass ratio is $q \approx 0.15 - 0.45$. Svechnikov et al. (1989) note that majority of low-mass detached systems during evolution not become ordinary semidetached systems. For detached systems with orbital period ($P \leq 1.3$ day), the angular momentum loss occurs due to magnetic stellar wind (MSW).

Due to fast loss of angular momentum with too small mass loss, the large semiaxis decreases and contact configurations is formed. Author pointed on transition of detached systems to KW, if $A \approx 10R_{\odot}$. If $A \leq 10R_{\odot}$ (the top of prohibited region), it is possible the transition DS$\rightarrow \sim$ KW $\rightarrow$ KW during $2 \times 10^8 - 4 \times 10^9$ years.

Many semi-detached systems are formed from DS due to role exchange with an angular momentum loss. A small group of low-mass DS with short periods (R CMa - type) evolves with angular momentum loss and strives to the contact if $A \approx 3R_\odot$. This group of binaries in the course of role exchange happens mass loss in surrounding area. For example, EE Aqr, YY Cet are low-mass CE-stars, which appeared from semi-detached R CMa-type systems. According the Catalogue by Bondarenko and Perevozkina (1997):

	μ_1	μ_2	q
EE Aqr	97%	100%	0.32;
YY Cet	93%	103%	0.49.

Such CE-systems as X Car ($\mu_1 = 99\%$, $\mu_2 = 94\%$, $q = 1$) and GK Cep ($\mu_1 = 99\%$, $\mu_2 = 98\%$, $q = 0.92$), according to Svechnikov and Snezhko (1974), became contact stars on the main sequence without role exchange.

In the work by Pustylnik (1989) also it is pointed on evolutionary transition among classes of close binaries: DS→ SDS→ KW. For example, the author says, that YY Cet passes to KW-type. The systems BF Aur, V1425 Cyg, RT Scl are on the stage before role exchange, after that KW-system of A-type will be formed. But all these systems are concerned to be CE-stars (Bondarenko and Perevozkina, 1997) at present and have parameters:

	μ_1	μ_2	q
BF Aur	97%,	99%,	0.99;
V1425 Cyg	95%,	102%,	0.39;
RT Scl	93%,	125%,	0.43.

Thus, according to criterions of devisions of CE-system into evolved and unevolved (after and before role exchange), BF Aur - before role exchange, V1425 Cyg and RT Scl - after.

Learned by Karetnikov (1989) diagram of degrees of filling of Roche-lobes has an evolutionary character, too. Suggesting that ∼KW and KW consist of the stars of main sequence with 100% filling of their Roche-lobes, one can suggest such evolutionary chain ($M_1 \leq 1.5M_\odot$) :

DS→ ∼KW→ KW.

The author showed that the filling of Roche-lobe was not connected with hydrogen burning in core and its squeezing, but decreasing of period and large semiaxis take place due MSW. These pointed transitions are possible for systems with $P < 3$ days.

The transition DS→ ∼KW passes during $8.7 \times 10^7 - 2.1 \times 10^9$ years, it is demanded 3.5×10^7 years for transition ∼KW to KW. However, if to examine the Karetnikov's diagram, appeares the idea about the following transition:

SDS→ CE, SDS→KW.

But the author did not examine that transition. The regions of CE and KW are crossed on the diagram.

Conclusion

1. For loss-mass close binaries (if one component has mass $M \leq 1.5M_\odot$, $A \leq 10R_\odot$, $P < 3$ days), there are possible the next evolutionary transitions:

a) DS→ SDS (R CMa-type) → CE,
DS→ ∼KW → KW
(Svechnikov et al., 1989);
b) DS→ ∼KW → KW (Karetnikov, 1989).

2. Including CE-stars in examination of the evolution of low-mass binaries systems possible next transitions (on the base primary mass - large semiaxis diagram):

DS→ SDS → CE (→ KW ?),
DS→ CE (→ KW ?) .

(Bondarenko and Perevozkina, 1997).

Problems:

1. It is possible the formations of low-mass CE to KW? If it is possible, how to explain great loss of matter?
2. Is it possible the formation of CE-systems from ordinary (not R CMa-type) SDS systems?
3. How to answer the question of Karetnikov (1989): what mechanism prevents from merging of the components of KW systems in one star? Are there any data about formation of one star from close binary?

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