STATISTICAL RESEARCH IN EVOLUTIONARY GENETIC RELATIONSHIP OF DMS-, DW-, KW- AND KE-TYPES OF DOUBLE STARS

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ABSTRACT. Statistical relations as spectrum-period, mass of primary component-semi-major axes of an orbit, excesses of luminosity and radius-mass of component, Karetnikov's diagram, modern and initial distributions of the binaries in the 1 ps^3 of Sun neighbourhood allow to solve the problem of evolutionary relationship for close binary systems and describe conditions at which evolutionary transitions such as DMS $\rightarrow$ DW $\rightarrow$ KW $\leftarrow$ KE take place.

Key words: Stars: close binaries: detached systems: W UMa-stars.

1. Introduction

In this paper we tryed to estimate the degree of evolutionary relation of close binary systems of DMS, DW, KW, KE types located on the Main Sequence MS and are in the "first phase of the mass exchange". These abbriviations are adopted according to classification by (Svechnikov M. A. et.al., 1980). The "Catalogue of approximate photometric and absolute elements of variable stars" is the basis of our research (Svechnikov M. A. et. al., 1990). Content of this catalogue is 437 DMS, 153 DW, 215 KW and 392 KE systems. The summary sample is greate enough to construct statistical diagram.

2. Basic statistical diagrams

Figure 1 plots distributions of given systems on the diagram lgM1-lgA. Two solid lines $A_{min}(q = 1)$ and $A_{min}(q = 0.3)$ restrict fields of distributions of DMS, DW, KW, KE systems. A_{min} is evaluated from $A_{min} = R(M1) \cdot q^{0.2084}/0.378$, $0.1 \leq q \leq 1$ (Plavec M. et. al., 1964), that is interpreted as a least distance between components at which the probability of discovering of double system as eclipsing variable is maximum.

So the large number of DMS stars should be located near line $A_{min}(q = 1)$. But in actual it is true only for systems with primary masses $M1 \geq 10$ Mo. One can see the region poor of DMS systems and known as "forbidden triangle" with coordinates $(lgM = 0, lgA = 0.9), (lgM = 0, lgA = 0.3), (lgM = 0.7, lgA = 1)$. It is not possible to explain this deficiency by effects of observational selection.

In paper by (Tutukov A. V. et.al., 1982) it is shown that for systems with $M1 > 1.5$ Mo the distance between components can not be less than it is allowed by expression $A/Ro = (6 \cdot M1/Mo)^{1/3}$. Whereas nothing prevents systems with $M1 \leq 1.5$ Mo to fall into "forbidden triangle", because such systems have an extensive convective envelopes characterizing by high degree of turbulence and differential rotation. As a result of dynamo action the magnetic field is generated and interacts with stellar wind emanating from the star. Thus in a binary system by magnetic breaking spin angular momentum loss (AML) results in orbital AML.

It is equivalent to components approaching. If velocity of approaching is greater than nuclear evolution rate components not being contact will have small values of A_{min}. But it is namely class of DW-systems. Having continued evolution in a scale of AML DW-systems may turn into KW-systems. The same range of primary masses can be considered as inderect evidence favor such evolutionary transition.

On the basis of analysis of this diagram we would like to propose the following evolutionary chain DMS$\rightarrow$DW$\rightarrow$KW. Such transitions have been investigated by various authors (Svechnikov M. A. 1990, Schatzman E., 1962, Vilhu O., 1982) and here are confirmed on the basis of much more numerous sample (800) from catalogue (Svechnikov M. A. et.al., 1990). Some of KE-systems also fall to "forbidden triangle" and so they may be included into similar scheme DMS$\rightarrow$KE$\rightarrow$KW.

Figure 2 shows distributions of systems on the diagram period-spectrum $lgP - Sp1$. If third Kepler's law is substituted in Tutukov's expression that at $q = 1$ value of $P = \sqrt{2.9/(1 + q)}$ is equal $1.^d2$. Visible DMS-distribution shows deficiency of these systems with $M1 > 1.5$ Mo and $P < 1.^d2$. Svechnikov is first who noted deficiency of such DMS stars (Svechnikov M. A.,

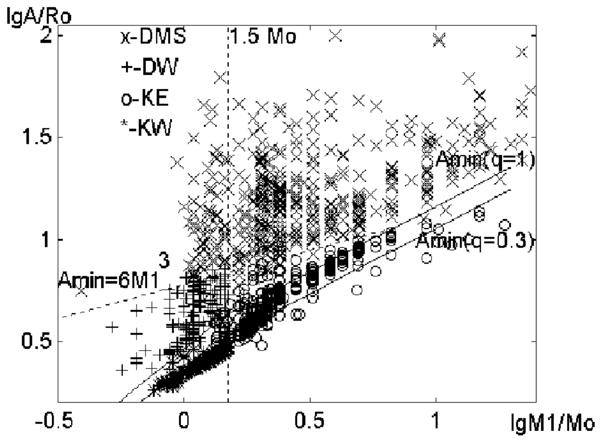

Figure 1: Distributions of DMS,DW,KW and KE stars on the diagram mass of primary component versus semi-major axes

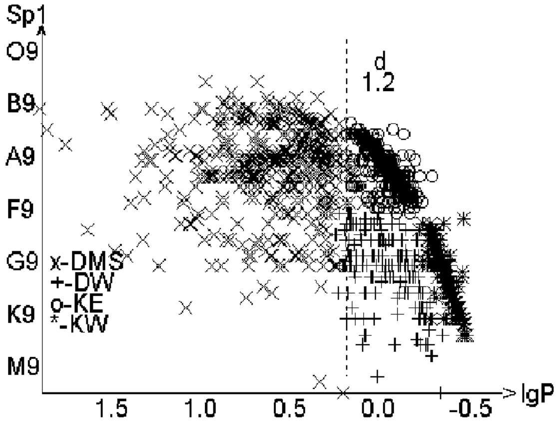

Figure 2: Distributions of DMS, DW, KW and KE stars on the diagram spectrum of primary component versus period

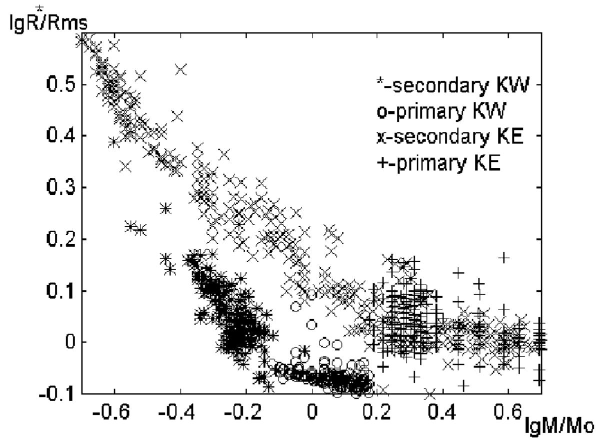

Figure 3: Distributions of KW and KE stars on the diagram radii excess versus mass of component

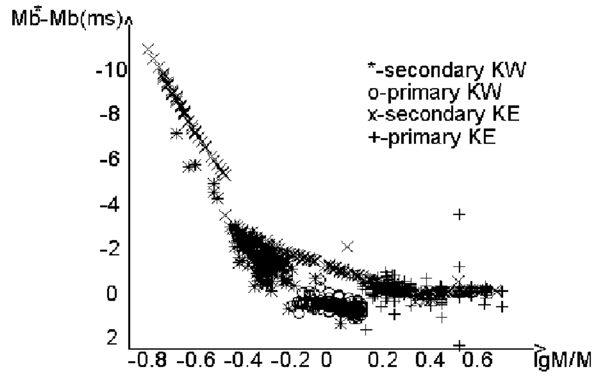

Figure 4: Distributions of KW and KE stars on the diagram luminosity excess versus mass of component

1969). Given diagram serves as one more illustration for this evolutionary transition mechanism. Here one can see the period gap equal 12^h, which is not filled by any systems. This is a bifurcation orbital period that means two possible evolutionary paths with formation converging ultra-close or diverging wide binaries. In our case the class of KW systems describes the first scenery while KE-systems correspond to second variant. The gap origin can be explained by quick choice of evolutionary path by systems of both classes.

Figures 3,4 reflect radii and luminosity excesses versus component mass. Excesses are determined as difference between observed (L) or calculated from observations (R) values and analogous magnitudes but proper to MS stars. DW systems have no radii or luminosity excesses niether for primary no for secondary components. It is expectable because they are close to DMS systems. For KW-satellites appreciable radii and luminosity excesses are exposed while in the case of KE-satellites they are expressed more strongly than for KW systems.

For interpretation of these excesses "role change" for KE class and "mass exchange" for KW class can be proposed. Before "role change" KE-satellites were primary components, which had enough time to evolve from the MS. As for KW-satellites due to orbital decay caused by AML, sizes of Rosha's lobe decrease and thus it is required less time to fill lobe space. In paper by (Istomin L. F., 1986) it is shown that increase of luminosity excesses for KW-satellites takes place due to release of gravitational energy of matter flowing from more massive component.

Karetnikov's diagram (Karetnikov V. G., 1988) (Figure 5) depicts the relative Rosha's lobe fullness versus degree of Rosha's lobe fullness by component. It is well seen that process of "role change" in the KW-systems

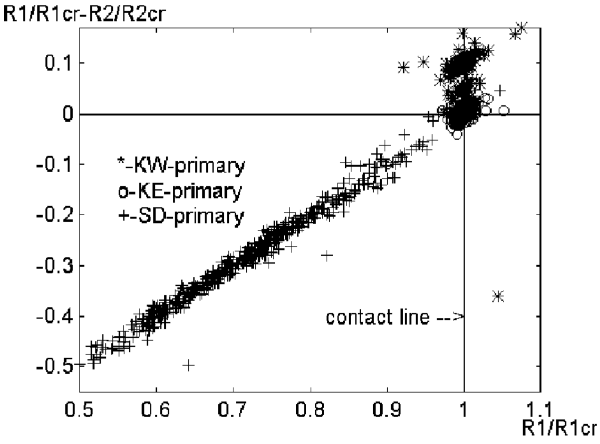

Figure 5: Distributions of SD, KW and KE stars on the diagram by Karetnikov

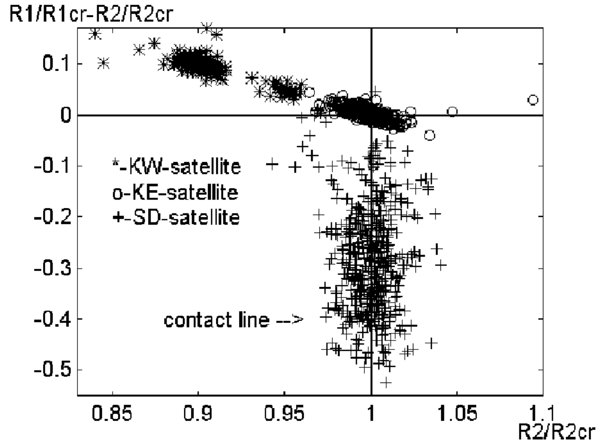

Figure 6: Summary modern spatial distributions of DMS, DW, KW and KE stars

never occured and almost all KW-primaries have overflowed Rosha's lobes while their satellites have no. Primary and secondary components of some KE-systems already intersected contact line.

For SD-systems of R CMa-type with $P < 1.^{d}2$ one component of which is subgiant while another is MS star it is proved that following relations $R1/R1_{cr} \leq R2/R2_{cr}$, $R2/R2_{cr} \geq 1$, $R1/R1_{cr} \rightarrow 1$ are true. It means that the process of "role change" in these systems takes place. Field of SD-distribution partially overlaps field of KE-distribution from this one has probable evolutionary transition SD- into KE-systems.

The next part of our work concerns the modern and initial distributions common presentations of which are $F_m(M1_i, P_i) = f_i/(V_i * W_i)$ and $F_{in}(M1_i, P_i) = f_i/(V_i * W_i * \tau_i)$. These functions are presented as spatial densities of close binary systems containing in the 1 ps^3 of Sun neighbourhood. $W_i(M1, A, q, i)$ and $W_i(M1, q, i)$ are probabilities of discovering for DMS, DW and KW, KE systems, respectively. By linear consequent interpolation between tabular values (Svechnikov M. A. et. al., 1989) we calculated individual W_i^* for each system of every class.

Then we estimate volume V_i for each system independently from it's classification as volume of spherical layer with thickness 180 ps (Istomin L. F., 1978). Radius is taken from equation $Mb_i = mv_i + \Delta mb_i + 5 - 5 \cdot \lg r_i - \overline{A} \cdot r_i$ which is solved with use of average interstellar absorbtion effect. $Mb_i = Mb1_i - \Delta m'$ is absolute bolometrical stellar magnitude of system as a whole in the brightness maximum, mv_i is absolute visible stellar magnitude of system as a whole in a brightness maximum, $\Delta m' = 0.^{m}48$ (Taidakova T. A., 1981), Δmb_i is bolometrical correction (Allen K. U., 1977), $\overline{A} = 0.0019 ps^{-1}$ is average interstellar absorbtion (Popper D. M., 1980).

τ_i is age of binary system of DMS, DW classes estimated by isochrone method constructed on the basis of evolutionary tracks by Maeder and Meynet with effects of overshooting and mass loss (Dryomova G. N., 1999). f_i is factor of sample incompleteness.

3. Conclusion

All distributions are presented as maps of intensities of given systems in coordinates (lgM1, lgP). So the modern DMS-distribution is quasi negative to one's own initial distribution because positions of local minima and maxima change their places.

The modern DW-distribution continues modern DMS-distribution. Upper boundary of modern KW-distribution is lower boundary of DW-distribution. In actual the initial DW-distribution should be absent and as a support of our proposition we can consider close to zero intensities. We conclude that DW abd KW classes reflect initial and modern distributions respectively of the same evolutionary class of contact double systems.

Figure 6 shows summary modern distribution of all

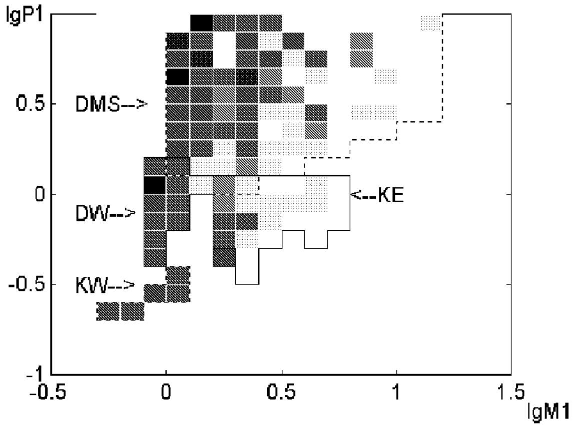

Figure 7:

considered here stellar classes and demonstrate their evolutionary migration. DMS, DW, KW classes intersect each other and the proximity of KW and KE classes permits to assume evolutionary transition KE into KW systems.

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