THE CATALOGUE OF PHOTOMETRIC, GEOMETRICAL AND ABSOLUTE ELEMENTS OF CONTACT BINARY STARS OF THE EARLY SPECTRAL TYPE

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ABSTRACT. The Catalogue of the early type contact systems is described and it's analysis is presented.

Key words: Stars: contact early binary systems (CE-systems); photometric, geometrical and absolute elements; diagrams of physical characteristics.

Catalogue

For the first time the early type contact systems were identified as an individual class in the Catalogue by Svechnikov (1969), which contains 8 systems of this type. The Catalogue by Coch et al. (1970) contains 37 systems of the early spectral type.

According to Svechnikov's classification a primary component (more massive and hotter) of a CE-system has a spectral class earlier than F0-F2 and an orbital period of more than 0,5 day. Usually the spectral class of a primary is earlier than the spectral class of a secondary. Both components fill their Roche lobes on 90-100 per cent and more. The following Catalogue by Svechnikov and Bessonova (1984) contains 38 CE-systems. Bondarenko (1986) published the Catalogue of the CE-s tars, which contained 83 systems.

Physical characteristics of the CE-stars presented in the list of catalogs abovementioned, were obtained by different authors by using different methods of calculation.

We propose the Catalogue of the CE-systems with homogeneous absolute physical characteristics, that allows to define accurately general features of this class of binary stars. The comparing of physical characteristics of the CE-systems with other classes'characteristics of binary stars can show the possible evolutionary stages of the CE-systems.

The foundation of absolute elements of the CE-systems are the spectral observations (radial velocity curves of the both components or radial velocity curve of the primary) and photometric observations (on the whole, the latest multicolour photoelectric, in a few cases photographic and visual observations). The accuracy of modern photometric observations is high, and generally they are processed with the help of reliable computer methods both classical and synthetical methods. But reliable spectral obser vations (the ray speed curves) are very scarce, especially for both components. We have prefered the spectral class of a primary (usually it is more bright), supposing, that it's spectral class was defined accurately, and photometric and geometrical elements from light curves.

Our Catalogue contains 100 CE-stars; 31 systems have the ray speed curves of the both components, 12 systems have the ray speed curve of the primary.

All stars from our Catalogue were classificated preliminarily as CE-stars by Svechnikov et al (1980). The absolute elements of other stars of the Catalogue were obtained by using a spectral type of the primary and the diagram mass ratio – observed radius of the component.

Our Catalogue consist of three parts: photometric, geometrical and absolute elements of CE-systems. All stars were divided approximately into two groups: massive ($M_1 > 3M_\odot$ for primary) and less-massive stars ($M_1 < 3M_\odot$ for primary).

Hertzsprung - Russell (H-R) diagram

On this diagram primaries and secondaries of the massive stars are locate near ZAMS, the width of ZAMS make up 3 spectral subclasses on the average. The spectral classes of primaries (O7-B3) are determined unreliablly, becose take place the lines' superposition of gas streams and shells, and it leads to deviation within the 0.5 spectral class.

The primaries of the less-massiv stars locate near ZAMS too, but secondaries have an excess of luminosity as compared with the normal stars corresponded to theese spectral classes, becquse they have more large sizes after filling Roche lobes. Several secondaries of less-massive stars deviate to the left from ZAMS, therefore, they have hagher temperature as compared with normal stars of main sequence, becquse they are the members of CE-systems, which exchanged their roles.

The mass-absolute bolometric magnitude diagram

The majority of primaries and secondaries are located more to the left from the same relation for detached binary stars of main sequence. The CE-systems have excess of luminosity nearly the $1^m - 2^m$, because of filling of their Roche lobes. The following relations take place for primary

$$M_{1bol} = -8.8126 \lg M_1 + 3.868$$
$$\pm 0.154 \qquad \pm 0.220$$

and for secondaries is

$$M_{2bol} = -7.609 \lg M_2 + 2.337$$
$$\pm 0.137 \qquad \pm 0.238$$

Secondaries of the less-massive CE-stars have significant excess of luminocity $2^m - 4^m$.

The mass-radius diagram

This diagram shows the location of CE-systems as compared with detached binary stars. There are components of massive CE-systems not far from the same relation for detached systems. Dispersion of CE-stars shows differehent evolutionary status because of different degree of Roche lobes filling.

The stars with the $M_1 > 10M_\odot$ have significant excess from the same relation. It is explained by very reliable spectral observations because of spectral line's superposition of both components. The primaries with $1.4M_\odot < M_1 < 3.2M_\odot$ correspond to $M - R$ relation for detached stars, but at the same time secondaries have significant excess of radii as compared with detached stars. It is one of the most important differences of CE-stars, especially from W UMa-type. The mass-radius relation for the primaries is

$$\lg R_1 = 0.620 \lg M_1 + 0.161$$
$$\pm 0.059 \qquad \pm 0.084$$

for secondaries is

$$\lg R_2 = 0.581 \lg M_2 + 0.234$$
$$\pm 0.040 \qquad \pm 0.070$$

We think, these stars experienced an exchange of roles. The excess of radii for the secondaries explains the excess of luminosity as compared with the normal stars of main sequence.

The mass - spectral class diagram

Primaries correspond to M-Sp relation for normal stars of main sequence, because we have supposed that primaries are normal stars. B1 - G0 secondaries are below, i.e. these components had a transfer of matter. The majority of G0 - K9 secondaries locates above. It is possible, these pairs of stars do not have any role exchange. Thus, such location of CE-stars on the M-Sp diagram points to different evolutionary stages of binary stars. The mass-effective temperature relations for primaries and secondaries are

$$\lg T_{1eff} = 0.547 \lg M_1 + 3.784$$
$$\pm 0.040 \qquad \pm 0.060$$

$$\lg T_{2eff} = 0.463 \lg M_2 + 3.881$$
$$\pm 0.038 \qquad \pm 0.066$$

The primary mass - semimajor axis

This is one of the most interesting diagram regarding evolution of binary stars. For the first time such diagram appeared in Svechnikov (1969). The region of co-ordinates

$$\lg M_1 = 0.0; \quad \lg A = 0.9,$$
$$\lg M_1 = 0.0; \quad \lg A = 0.5,$$
$$\lg M_1 = 0.7; \quad \lg A = 1.0$$

was called a region of absence for unevolved close binaries stars. Later CE-stars from (Bondarenko, 1986) filled that region. And our new investigations confirm this. This region is filled as the unevolved stars as evolved components (i.e. they experienced role exchange). Rich information about CE-systems (majority of them are dull objects) allows to make the following conclusion: the CE-stars fill the "prohibited" region. The solid lines shows minimal value of orbital semimajor axis with fixed mass ratio for normal stars, which correspond M-R relation, if they fill their Roche lobes.

Conclusions

As a result of CE-systems study we can propose the following conclusions:

1) the components of CE-stars influence each other greatly and increase their evolutionary processes;

2) primaries components (more massive and hotter) satisfy general relations of physical characteristics for normal stars of main sequence;

3) majority of secondaries satisfy the same relations too. But many of secondaries have differences, which make up the CE-systems as an individual class of close binaries stars. Secondaries have an excess of luminosity and excess of radii;

4) due to the fact that mass transfer take place in close binary stars, many of them exchanged their roles and became CE-systems (the evolved CE systems). But many of them became CE-stars wthout role exchange, being the stars of main sequence;

5) both components fill their Roche lobes within 90-100% and more.

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