ON THE STATE OF SUBGIANT-STARS' NUCLEI IN ECLIPSING BINARY SYSTEMS

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ABSTRACT. It is shown that subgiants in SD-systems with the mass ratio $q \leq 0.25$ and DS-systems have degenerated helium nuclei whereas subgiants in SD-systems with $q \geq 0.25$ and of AR-systems have not.

Among eclipsing binary stars there are three types of systems involving a subgiant-star wherein one can expect the existence of a degenerated helium nucleus. These are SD-, DS- and AR-stars systems, besides, in the first two types the companion of lower mass is a subgiant whereas in AR-systems both stars of the pair do, having masses nearly equal in values.

Then after formulae (4) and (5) in Iben and Tutukov (1984) for the stars with a degenerated nucleus the variation of nucleus mass M_c can be determined by means of radius R in the formula below

$$M_c = b \times c^{-\beta/\gamma} \times R^{\beta/\gamma} (M_\odot/yr), \qquad (1)$$

where the constants $b = 10^{-5.36}$, $c = 10^{3.5}$, $\beta = 6.6$, $\gamma = 4$. The constants describe the case of the degenerated helium nucleus in the burning up of hydrogen in a layer source.

Assuming that the star's luminosity can be determined by the energy output in the hydrogen burning with efficiency $\varepsilon = 6 \times 10^{14}$ J/kg that changes the nucleus mass,we can express the star's luminosity in the form

$$L = \varepsilon \times M_c, \qquad (2)$$

that in the absolute bolometric magnitudes M_b can be expressed using (1) by the formula

$$M_b = 5.16 - 4.12 \times \log R. \qquad (3)$$

The comparison of empirical luminosities and radii of subgiant-stars invol-

ved in SD-, DS- and AR-systems according to the catalogue data (Karetnikov and Andronov, 1989) allows to determine the "radius-luminosity" relations in the form

$$
\begin{array}{lll}
\text{SD-systems:} & q \leq 0.25, & M_{b2} = \underset{\pm 16}{5.37} - \underset{\pm 31}{4.74} \times \log R_2,\ k = \underset{\pm 06}{0.94},\ n = 32 \\
 & q \geq 0.25, & M_{b2} = \underset{\pm 44}{5.74} - \underset{\pm 78}{7.29} \times \log R_2,\ k = \underset{\pm 09}{0.83},\ n = 42 \\
\text{DS-systems:} & & M_{b2} = \underset{\pm 94}{4.93} - \underset{\pm 1.22}{4.14} \times \log R_2,\ k = \underset{\pm 23}{0.77},\ n = 10 \\
\text{AR-systems:} & & M_{b1} = \underset{\pm 27}{4.13} - \underset{\pm 54}{3.14} \times \log R_1,\ k = \underset{\pm 15}{0.88},\ n = 12 \\
 & & M_{b2} = \underset{\pm 40}{4.29} - \underset{\pm 92}{3.48} \times \log R_2,\ k = \underset{\pm 20}{0.77},\ n = 12.
\end{array}
\qquad (4)
$$

Here q is the masss ratio of stars' pair, k is the correlation coefficient, n is the number of objects used, index "1" is given to a more massive star's of pair, index "2" - to a less massive one. It should be noted that in calculations there are excluded SZ Cen (AR-system), Z Ori (DS-system) as distinctly different from the stars of their classes, as well as all the massive SD-systems SZ Cam, XZ Cep, V448 Cyg, V453 Sco, V356 Sgr, RZ Sct giving a separate dependence not corresponding to (3) and RY and AB Per (SD-systems) that have $q \leq 0.25$ but by their radii and luminosities are within the range of SD-systems with $q \geq 0.25$.

The analysis of formulae (4) shows that "radius-luminosity" relations approach the theoretical dependence (3) for subgiants of DS-systems and subgiants of SD-systems in the group with $q \leq 0.25$. The rest groups of subgiants (SD-systems with $q \geq 0.25$, AR-systems) give dependencies far from formula (3). So one can surmise that degenerated helium nuclei should have subgiants of DS-systems and subgiants of SD-systems with $q \leq 0.25$. Subgiant-stars of other types of eclipsing binary systems do not seem to have degenerated helium nuclei.

The subdivision of SD-systems into two groups according to stars' mass ratio $q \gtrless 0.25$ has been carried out for the first time in Karetnikov (1987) and expresses the difference of subgiants in luminosity excesses. It is clear now that luminosity excesses are determined by the state of subgiants' nuclei: with the star's degenerated helium nucleus the luminosity excesses are big, with a nondegenerated nucleus the subgiants' luminosity excesses are not great. As both sequences of SD-systems converge in the region $\log R \approx 0.2$, $M_b \approx 4.2$, a part of subgiants of both groups meets both sequences, and this needs search for a more severe criteria for subdivision of subgiants according to the state of their nuclei.

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