EMPIRICAL DETERMINATION OF THE GRAVITY-DARKENING EXPONENT FOR THE SECONDARY COMPONENTS FILLING THE ROCHE LOBE IN SEMI-DETACHED CLOSE BINARY SYSTEMS

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The ordinary semi-detached close binary system consists of a main-sequence primary and subgiant (or giant) secondary component where the latter fills the Roche lobe. From a quantitative analysis of the observed ellipticity effect, Kitamura and Nakamura (1986) have deduced empirical values of the exponent of gravity-darkening for distorted main-sequence stars in detached systems and found that the empirical values of the exponent for these stars with early-type spectra are close to the unity, indicating that the subsurface layers of early-main sequence stars in close binaries are actually in radiative equilibrium. The exponent of gravity-darkening can be defined by $H \propto g^{\alpha}$ with H as the bolometric surface brightness and g as the local gravity on the stellar surface.

Thus, by assigning $\alpha_1 = 1$ to the early-type main-sequence primaries in semi-detached systems, similar practical analysis as done in the previous work of Kitamura and Nakamura (1986) has been carried out to determine empirical values of the exponent for the secondaries of those systems which fill the critical Roche lobe.

The result of the analysis indicates that the α_2-values deduced for the secondary components of nine well-understood semi-detached close binary systems are significantly greater than the unity, as shown in Table 1. Such greater values of the exponent for the secondaries of semi-detached systems could not be reconciled by any adjustment of the elements used as the input physical parameters within the extent of reduction errors (including uncertainties of the adopted temperature scales and limb-darkening coefficients). Also, such an excess of α_2-values for the secondaries is evidently in a direction opposite to that expected from convection for stellar atmospheres. In this connection, it may be noted that Budding and Kopal (1970) previously discussed the degree

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of gravity-darkening of the secondary component of Algol based on an analysis of the infrared light curve of its secondary minimum and reached the same conclusion of large gravity-darkening. They have deduced τ_λ / τ_0 = 0.26 $\pm$ 0.06 for the secondary of Algol, which corresponds to α_2 = 3.8 $\pm$ 0.6 in our notation.

Table 1. Empirical α-values determined for the secondary components of nine well-understood semi-detached close binary systems.

Star	T_2	log g_2	α_2
V Pup	26600°K	3.95	5.44 $\pm$ 0.16
TT Aur	17300	3.90	3.84 $\pm$ 0.22
u Her	12000	3.61	8.47 $\pm$ 0.51
Z Vul	8500	3.48	9.73 $\pm$ 0.12
LT Her	5200	3.73	5.86 $\pm$ 0.08
RZ Cas	5000	3.73	2.25 $\pm$ 0.15
W UMa	5300	3.96	3.78 $\pm$ 0.12
V356 Sgr	10300	2.83	3.83 $\pm$ 0.19
GT Cep	10000	3.05	3.00 $\pm$ 0.43

At present, we do not know what is the real origin of such excessive gravity-darkening for the secondary components of semi-detached systems. However, one possibility to explain such observational evidence may be found in the effect of mass loss from the secondaries (e.g., Unno, Kiguchi and Kitamura, in this Proceedings).

Full detail of the present analysis has been published quite recently elswhere (1987).

References

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