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ORIGINAL ARTICLE

# Tidal torque constants as a critical test for an evolution of close eclipsing binaries

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**Abstract** Individual tidal torque $\lambda_2$, $E_2$ and apsidal-motion $k_2$ constants were calculated for 112 close eclipsing binaries (*CEBs*) with Detached components belonging to the Main Sequence (*DMS*-type) from the catalogue by Svechnikov and Perevozkina (Catalogue of orbital elements, masses and luminosities of variable stars of DMS-type and some results of its statistical treatment, Ural State University Press, Yekaterinburg, pp. 1–5, 1999) and for 95 detached binaries taken from the catalogue by Torres et al. (Astron. Astrophys. Rev. 18:67, 2010) on the base of theoretical evolutionary stellar models including tidal torque constants by Claret (Astron. Astrophys. 424:919, 2004). A method of the inversion of model track grid into isochrones was formulated as a complex interpolation procedure for DMS-binaries data. Sets of isochrones were computed in $k_2$–$M$, $k_2$–$R$, $\lambda_2$–$M$, $\lambda_2$–$R$, $E_2$–$M$, and $E_2$–$R$ planes. Calculated tidal torque constants allow to test stellar structure theory by comparing observed and estimated values of apsidal motion period and analyzing the correlation between timescales of synchronization, circularization, magnetic braking, as well as nuclear burning of *DMS*-components.

**Keywords** Close eclipsing binaries · Tidal-evolution constants · Apsidal motion

## 1 DMS-class and basic binary classification

The most informative objects in astrophysics are close eclipsing binaries (*CEBs*) with double-line spectrum. The eclipse periodicity of the components makes theirs the unique instrument for the measurement of important stellar parameters such as masses and radii. The combined solution of the photometric light curve and the spectroscopic radial velocity curve gives full set of orbital elements being necessary when studying stellar interior. The understanding of the internal structure of the star raises more complex problems linked with the evolution and multiformity of stellar binary systems. The modern sophisticated classification of close eclipsing binaries elaborated by Svechnikov (1969) is based on the simple criteria such as the localization of the components of close binaries on Hertzsprung-Russel diagram and Roche lobes filling degree.

This classification scheme, integrating advantages of the classification by Kopal (1955) accounting for geometrical characteristics of the stars only and the classification by Krat (1962) based on physical parameters of the components, proved to be convenient for statistic analysis. Despite of external characters the classification by Svechnikov (1969) turns out to be connected with evolutionary stages of binary systems defined by its age and initial physical parameters. According to this classification all the multiformity of eclipsing binaries may be subdivided into the following types (classes):

1. *D*etached *M*ain *S*equence (*DMS*) type designates binary systems in which both components locate within the Main Sequence band and have not filled their inner Roche lobes yet;

2. *S*emi-*D*etached (*SD*) type is for binaries one component of which is a normal star belonging to the Main Sequence and not filling its inner critical surface, but the secondary less massive star is a subgiant with significant luminosity and radius excesses close in size to the Roche lobe;

3. *D*etached with *S*ubgiant (*DS*) type defines binaries composed of normal Main Sequence star and subgiant with

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