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Rotation and tide equilibrium

A statistical analysis of the observations

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Abstract. WWe used an unprecedented new sample of 1538 binaries of spectral types O-K, and luminosity class V, IV and III. The goal here is to find the period which binaries reach the synchronization between rotational and orbital periods, and orbital circularization. Our results are confronted with tidal theory by Zahn.

Resumo. Nós usamos uma nova amostra sem precedentes de 1538 binárias dos tipos espectrais de O a K, e classe de luminosidade V, IV e III. O objetivo aqui é achar o período que as binárias alcançam a sincronização entre os períodos rotacional e orbital, e circularização orbital. Nossos resultados são confrontados com a teoria de maré de Zahn.

Keywords. Spectroscopic binaries – Rotation – Star evolution

1. Introduction

Binary systems can provide sufficient observable for tests of stellar evolution models. It is estimated that more than half of the stars are components of multiple systems. In a binary system the two components are gravitationally bound to each other move in elliptical orbits around their common center of mass. These stars can provide more observable than simple stars.

All binary system, as well as all physics system, search the equilibrium. For binary systems are necessary three conditions: synchronization, circularization and all spins, orbital and rotational, aligned. All these parameters pass by process of evolution, these process are: the tidal effect, angular momentum loss by magnetically coupled, stellar wind and by gravitational wave radiation, strong wind accretion and Roche-lobe overflow characterizing mass transfer (Duquennoy, Mayor, & Mermilliod, 1992).

Zahn relates the efficiency of the tidal effect to the turbulent friction in the convection zone of the star, states the theoretical period for most likely system be synchronized and circularized, and calculates the time of synchronization and circularization.

$$\frac{1}{t_{sinc}} \approx 6\frac{k_2}{t_f}q^2\left(\frac{MR^2}{I}\right)\left(\frac{R}{a}\right)^6, \qquad (1)$$

$$\frac{1}{t_{circ}} = -\frac{d\ln(e)}{dt} = \frac{21}{2}\frac{k_2}{t_f}q(1+q)\left(\frac{R}{a}\right)^8, \qquad (2)$$

We evaluated the relationship between orbital period, rotational velocity and eccentricity. For different subsamples based on spectral type, we found a critical period of synchronization and we discuss about circularization and statical properties regarding this spectral type and luminosity class.

2. Sample

The spectral types and luminosity class was collected of the data base from SIMBAD.

The orbital period and eccentricity was collected from the online version of the Ninth Catalog of the Orbital Elements of Spectroscopic Binaries. (Pourbaix et al., 2004). The mean rotations were collected from Catalog of Projected Rotational Velocities (Glebocki & Gnacinski, 2003).

Table 1. Quantity of stars by spectral type, evolved and not evolved.

S. T.	V	(IV and III)
O0 to O9	26	17
B0 to B4	85	89
B5 to B9	95	59
A0 to A4	174	49
A5 to A9	47	29
F0 to F4	68	28
F5 to F9	194	45
G0 to G4	128	66
G5 to G9	84	133
K0 to K9	109	201

3. Results and conclusions

The main sequence stars synchronize with periods about 17 days, in other hand the subgiants and giants synchronize about 580 days.

For the values of circularization we find about 14 days for main sequence and 400 days for subgiants and giants range.

The correlations among period and rotation, and among excentricity and rotation are more significant starting in spectral type F5, for not evolved stars and starting in spectral type G for evolved stars.

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References

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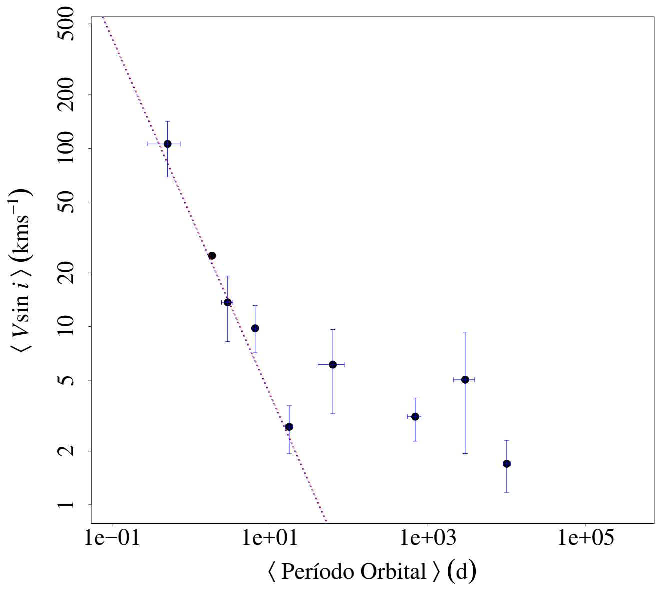

Figure 1. Syncronization of main sequence G stars. The red lines indicate the greatest radii and the blue lines indicate the smallest radii

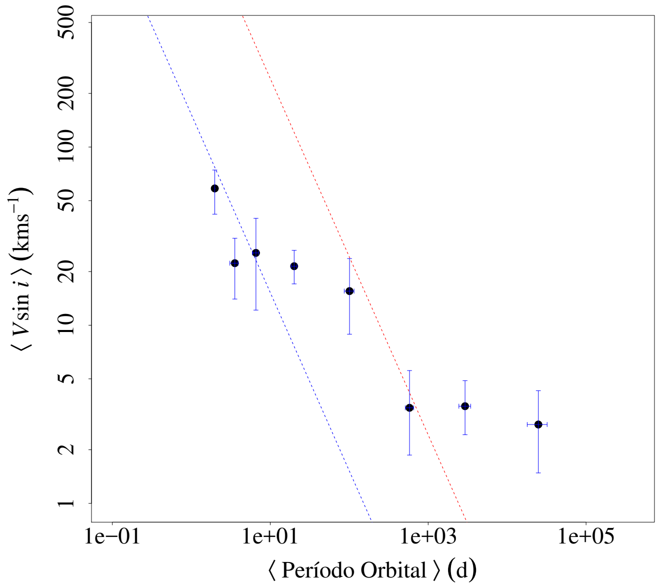

Figure 2. Syncronization of K giants and subgiants. The red lines indicate the greatest radii and the blue lines indicate the smallest radii

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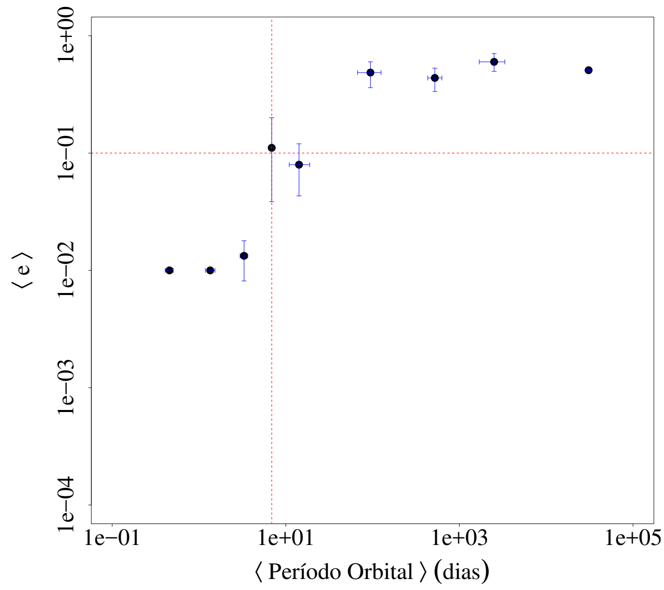

Figure 3. Circularization of main sequence K stars. The horizontal line indicates the circularization and the vertical line indicates the critical period.

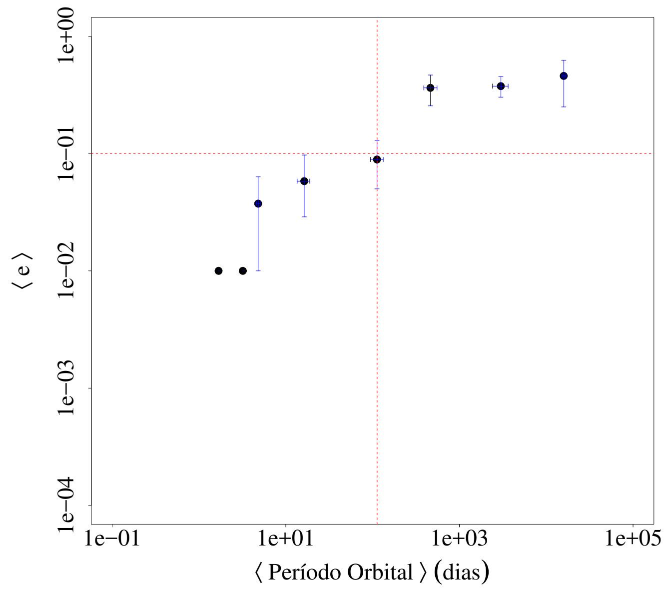

Figure 4. Circularization of G giants and subgiants. The horizontal line indicates the circularization and the vertical line indicates the critical period.