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CCD Photometric Study of the Puzzling W UMa-type Binary TZ Boo

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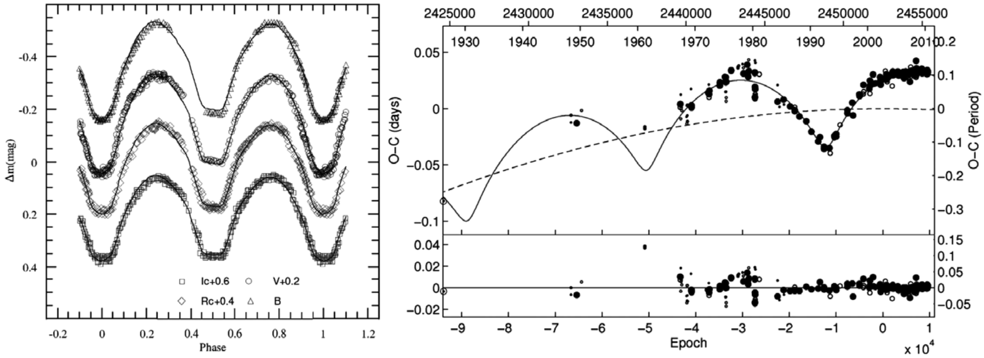
Abstract. The puzzling W-UMa type binary TZ Boo has been monitored at the University of Patras, Observatory from March to July 2010. Photometric solutions were determined through an analysis of the complete BVRI light curves with PHOEBE (Wilson-Devinney code) and published spectroscopic data. This low mass ratio binary turns out to be a deep overcontact system with f = 52.5% of A-subtype. A conservative spot model has been applied to fit the particular features of light curves. Based on our 7 new light minimum times and all others compiled from the literature over 70 years, we studied the orbital period from the O-C curve.

1. Introduction

The system TZ Bootis (BD +40^{o}2857=HIP 074061=GSC 3045.00893, $\alpha_{J2000} = 15^h08^m$ 09.1^s and $\delta_{J2000} = +39^o58^{'}13^{''}$, $V_{\max} = 10.45$ mag) is one of the most interesting and unusual W-UMa binaries because it has exhibited several changes in the period and in the depth of both minima (Awadalla *et al.* 2006) since its discovery by Guthnick & Prager (1927). Nevertheless there exists no modern photometric solution.

2. New CCD photometric observations and analysis

The system was observed on 2010 April 12, May 27 and June 7, 10, 11, 16 with the 35.5 cm $f/6.3$ Schmidt-Cassegrain telescope at the University of Patras Observatory and its SBIG ST-10 XME CCD camera and standard Johnson-Cousin-Bessel set of BVRcIc filters. GSC 3045 959 and GSC 3045-01495 were selected as comparison and check star, respectively. Seven light minima times were calculated with the software Minima25c (Nelson2005) using the K-W (Kwee & van Woerden 1956) fitting method. In our data, the appearance of the eclipses shows that TZ Boo is likely an A-Type rather than W-Type system. For the LC analysis, we used the Wilson & van Hamme (2007) code as implemented in the software PHOEBE (Prša & Zwitter 2005). The mean temperature value for star 1 (star eclipsed at primary light minimum) was taken to be 5890 K and the spectroscopic mass ratio $q = 0.207$ according to the last spectroscopic analysis (Pribulla *et al.* 2009), but during the final calculations it was an adjustable parameter. Considering the hypothesis that the orbital period variation on the system is due to the hypothetical third body, the third light was also included. In order to effectively model the flat secondary minimum where there is an obvious slope, a cool star spot was introduced on the primary component. The synthetic and observed light curves are shown in Fig. (a). We compiled all available light minimum timings up to date, from 1926 to 2010, which together with our seven new CCD observations, make a total of 412 (60 visual, 176 photoelectric and 176 CCD). We note that many of the published minimum times were misidentified for their types, so the O-C residuals computed by the ephemeris MinI=2452500.188+0d.2971604xE of Kreiner (2004) are incorrect. It might be caused by



(a) (b)

the varying depth of both primary and secondary eclipse and the continuously changing orbital period. After corrections for the type of eclipse, the computing code of Zasche *et al.* (2009) was used for the analysis whereas weight 1 was assigned to the reliable visual and photographic observations and weight 10 to the precise photoelectric and CCD. The general trend of (O-C) residuals can be described by a parabolic curve superposed with the sinusoidal oscillations (LITE, Irwin 1952). The final fit and the residuals of the analysis are presented in Fig. (b).

3. Conclusions

Our photometric results suggested that TZ Boo is a low mass A-subtype W-UMa type overcontact binary system with an over-contact degree $f = 52\%$. Combining our photometric solutions with the total projected mass from spectroscopy (Pribulla *et al.* 2009) and the orbital period $P = 0^d.2971599$ from the new ephemeris, the primary and the secondary components were found to have masses 0.99 $M_\odot$ and 0.21 $M_\odot$, respectively, and radii 1.08 $R_\odot$ and 0.56 $R_\odot$, respectively. The steady decrease of its orbital period $dP/dE = -0.17 \times 10^{-10}$ days/cycle is probably due to mass transfer from the more to the less massive component and/or angular momentum loss by the magnetic breaking which would cause the overcontact degree to increase, and finally the binary will evolve into a single rapidly-rotating star. The sinusoidal variation can be fit with an eccentric orbit ($e = 0.63$) and period 31.18 years. According to our photometric solution, its contribution is about 2.1%, in agreement with the upper limit of the spectroscopic results.

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