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Light curve and detailed model of the triple eclipsing binary system FI Boo

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Abstract. We present a detailed analysis of the interesting W UMa binary FI Boo in view of the spectroscopic signature of a third body, through new multicolor light curves obtained at the University of Patras Observatory "Mythodea", period variation, and a thorough investigation of solution uniqueness.

Key words: binaries:eclipsing-stars – fundamental parameters-stars:individual – FI Boo

1. Introduction

The low amplitude eclipsing system FI Boo (GSC 03488-00799,TYC 3488-799-1, V_{max}=9.49±0.02 mag, P=0.39 days) was discovered by the Hipparcos mission ESA (1997) and was studied spectroscopically by Lu *et al.*, (2001), Kjurkchieva and Marchev (2011) (hereafter Lu01 and KM11, respectively) and photometrically by Terrell *et al.* (2006) (hereafter T06) who classified it as an A-subtype W UMa. No solution taking into account the detection of a faint third component as suggested by D'Angelo *et al.*, (2006) (hereafter DA06), has been published until now.

2. Observational data and Analysis

We obtained new BVRcIc photometric light curves on April 30, and May 1 and 2, 2012 with the 35.5 cm f /6.3 Schmidt-Cassegrain telescope at the University of Patras Observatory "Mythodea" and its SBIG ST-10 XME CCD camera and a standard Johnson-Cousin-Bessel set of filters. TYC 3488-910-1 and TYC 3488-636-1 were selected as a comparison and check star, respectively. We used the RV originated value of $\alpha \sin i = 1.57 \pm 0.01\ R_{\odot}$, to constrain the solution of light curves (LC) to those values of α and i that preserve $\alpha \sin i$, using an "overcontact binary not in thermal contact" mode of PHOEBE and assuming circular orbits. In the case of FI Boo we found that we had to include a third source of light in the model light curves to be able to fit all passbands simultaneously. Before adopting our final solution we examined the derived solution with PHOEBE's scripter (Prša and Zwitter 2005) capabilities for uniqueness through a combination of heuristic scanning and parameter kicking performed on all adjusted parameters in 2000 iterations. Furthermore, in order to escape from local minima when

Table 1. The final derived parameters for the contact binary FI Boo

Parameters	Value	Parameters	Value	Parameters	Value
$\alpha(R_\odot)$	2.55±0.17	f (%)	50.15±8.10	T_h (K)	5746 ± 33
R_h $(R_\odot)$	0.85±0.07	R_c $(R_\odot)$	1.28±0.07	T_c/T_h	0.943±0.032
$i(^o)$	38.05±2.69	L_{Bh}/L_{tot}	0.28±0.02	T_c (K)	5420 ± 56
q=M_c/M_h	2.68±0.06	L_{Vh}/L_{tot}	0.27±0.02	$M_h(M_\odot)$	0.40±0.05
$g_h = g_c$	0.32 (fixed)	L_{R_ch}/L_{tot}	0.30±0.02	$M_c(M_\odot)$	1.07 ±0.05
$A_h = A_c$	0.5 (fixed)	L_{I_ch}/L_{tot}	0.26±0.02	$L_h(L_\odot)$	0.71±0.11
$L_c(L_\odot)$	1.27±0.14	$\Omega_h = \Omega_c$	5.89 ± 0.13		

convergence within a fractional accuracy was reached, parameters were kicked with respect to 5-10% of the value of a given parameter and minimization was restarted from displaced points. The values of adjusted parameters are then put into histograms from which the mean and the standard deviation of parameter values are calculated (Table 1). In this study, the spectroscopic ephemeris of LO1 and the photometric one of Pribulla et al (2002) are in agreement with our phased light curves with unequal depths, suggesting a W type for the system, in accordance with DA06 and K11. Furthermore, the investigation of the A-type solution of T06 resulted in an unstable solution. Nevertheless, there is a common phenomenon observed in several W UMa systems to fluctuate from the A type to the W type and it has to be further investigated. Although our preliminary derived third light component parameters - under the assumptions made from our solution- are in agreement with DA06, its contribution in the B passband is larger (0.30) compared to their value of 0.012, but, as noted by the authors, for flux ratios below 2%, the uncertainty of their method reaches 50 %. The smaller contribution to the system flux in the other passbands might suggest a blue subdwarf (sd) in the system, i.e., a star less luminous than main sequence stars of a similar spectral type. We have to point out that as the presence of the third light decreases the depth of eclipses and roughly simulates a system with lower inclination, under the clear detection of a third component by D06 we consider our solution as a probable explanation involving FI Boo in a triple system, although the nature of the third body still remains an open question.

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