Ten CoRoT eclipsing binaries: Photometric solutions [☆]

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ABSTRACT

Ten eclipsing binaries, identified in the scope of the CoRoT Space Mission, were selected for analysis. The photometric light curves were processed and analyzed, resulting in the first study of eclipsing binary candidates with their possible photometric solution, in the context of the above-mentioned Space Mission. The selected targets are detached and overcontact systems, for which we computed 2MASS temperatures, in addition to different physical parameters, including orbital period, orbit inclination angle, and temperatures, radius and luminosity ratios. This study reveals a large diversity of eclipsing binary systems obtained from the CoRoT data.

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1. Introduction

CoRoT (Convection, Rotation and planetary Transits) is a photometric space experiment, launched on December 27th 2006 in an inertial polar orbit at an altitude of 897 km. It is devoted to astero-seismology and the search for extrasolar planets using the transit method (Baglin et al., 2006). The instrument is fed by a 27-cm diameter telescope. During each run, it simultaneously provides light curves (variations in stellar flux with time) from 10 bright stars ($5.5 < m_V < 9.5$) dedicated to seismic studies, while 12,000 fainter stars ($11.5 < m_V < 15.5$) are monitored to search for transits caused by planets. Exhibiting a high-precision photometry of 100–600 ppm, combined with long time coverage of target areas, CoRoT also offers a unique possibility for the detection and study of eclipsing binary systems. In this context, we analyzed one thousand light curves from the CoRoT public data archive,¹ searching for transit signature of binary systems, from which we identified 10 binary eclipsing systems illustrating an interesting diversity of stellar binary families. With this preliminary study we also aim to alert the community to the large variety of binaries obtained from the CoRoT Space Mission data, which offer numerous possibilities for enlarging our understanding of the behavior and evolution of stellar binary systems.

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¹ <http://idoc-corot.ias.u-psud.fr>.

2. General analysis of the Corot targets

The basic parameters for our sample of 10 binary systems are displayed in Table 1. In addition to the star CoRoT code and coordinates (RA and Dec), Table 1 also shows the spectral type (Sp) and luminosity class (LC) of each system, extracted from CoRoT data base. Star ID 102622874, ID 102673160 and ID 102738809 were for the first time identified as eclipsing binaries in the scope of the present study, whereas ID 102764398, ID 102773399, ID 102794063, ID 102806409 and ID 102961901 were identified by Carpano et al. (2009) also on the basis of CoRoT data. Star ID 102750270 (*Gu Mon*) and ID 102940723 (*V515Mon*) are already known in the literature as eclipsing binaries, a status confirmed by CoRoT observations. It should be underlined that all the light curves analyzed in the present study come from the first long run observed by CoRoT, namely the IRa01, toward the galactic anticenter.

The study of eclipsing binary systems is based on the changes of light intensity from eclipsing binary stars that occur when one of the star transits in front of the other relative to the observer (Kopal, 1975). The 10 light curves were reduced with a standard pipeline developed at Laboratoire d'Astrophysique de Marseille (LAM) by the CoRoT Community (Samadi et al., 2007; De Oliveira Fialho et al., 2007). Different artifacts such as linear trends and discontinuities were removed from the original data. Due to the large PSF (point spread function) of CoRoT, a false binary may be found (Barge et al., 2008; Drummond et al., 2008). It should be underscored that an important detail to confirm the eclipse is to observe the eclipsing signature in the three photometric bands of the CoRoT mask separately. Such an aspect is observed for all the stars of the sample.

The orbital period of each binary system, listed in Table 2, was calculated using the DCDFT method (date-compensated discrete Fourier transform). In order to derive the physical parameters from the light curve, we used the PHOEBE programme (Prša and Zwitter, 2005) which functions based on the Wilson–Devinney algorithm (Wilson and Devinney, 1971). This programme was expanded to include flux computation in the CoRoT passbands

for both seismology and exoplanet fields (Maceroni et al., 2009). To find the best fit for these systems we used two types of Phoebe models for different types of binary systems, detached binary (ID 102673160, ID 102738809, ID 102764398, ID 102806409 and ID 102940723) over contact binary not in thermal contact (ID 102622874, ID 102750270, ID 102773399, ID 102794063 and ID 102961901). For the bolometric albedo and gravity darkening we

Fig. 1. The phase diagram of HD 50846 and CoRoT targets ID 102622874, ID 102673160, ID 102738809, ID 102750270, ID 102764398.

used the theoretical values for convective atmospheres, i.e. $A_1 = A_2 = 0.5$, $G_1 = G_2 = 0.32$ (Lucy, 1968) and these values were kept fixed. Specific limb-darkening coefficients were computed from Sing's table (Sing, 2010) using the quadratic law, which provides two $x_1(x_2)$ and $y_1(y_2)$ coefficients per star. The temperature of the primary stars (T_1) was kept fixed and calibrated from the color indices ($J - K$) provided from the 2MASS catalog, using the calibrations of Alonso et al. (1999).

All the stars have circular orbits except CoRoT ID 102673160, which has a very eccentric orbit with $e = 0.60968$ and argument of periastron $\omega = 0.91399$ rad. The parameters adjusted in the minimizations were inclination i , temperature of secondary star T_2 , primary passband luminosity L_i and surface potentials Ω_1 and Ω_2 . The mass ratio was set at 1.0 and when the adjustment of these parameters did not provide further improvement, we included mass ratio in the minimization calculation. For CoRoT ID 102673160 we first

Fig. 2. The phase diagram of CoRoT targets ID 102773399, ID 102794063, ID 102806409, ID 102940723 and ID 102961901.

Table 1

Basic information about the analyzed systems.

COROT ID	RA	Dec	Sp	LC	(J – K)	T_1
102622874	06 41 58.73	–00 04 38.86	F7	III	0.240	6360
102673160	06 43 05.43	–00 34 40.08	F8	IV	0.281	6095
102738809	06 44 31.53	+00 49 55.67	F2	III	0.247	6313
102750270 (Gu Mon)	06 44 46.85	+00 13 18.44	F2	II	0.130	7221
102764398	06 45 05.96	–02 48 40.36	F8	IV	0.444	5257
102773399	06 45 18.13	–00 57 00.40	G1	V	0.412	5399
102794063	06 45 46.02	–02 48 33.80	G8	V	0.584	4729
102806409	06 46 10.00	–03 08 55.46	A0	V	0.412	5399
102940723 (V515 Mon)	06 49 21.14	–02 06 48.82	A5	IV	0.249	6299
102961901	06 49 46.29	–02 01 05.81	G2	IV	0.583	4732

Table 3

Light-curve parameters of the individual systems (continuation).

COROT ID	Phsh	Ω_1	Ω_2	x_1	x_2	y_1	y_2
102622874	–0.241	3.619	3.619	0.359025	0.382100	0.282404	0.267984
102673160	+0.337	23.365	21.271	0.382203	0.380705	0.267842	0.268540
102738809	+0.443	11.272	6.343	0.361451	0.636541	0.282813	0.085011
102750270	–0.254	3.181	3.181	0.294220	0.293424	0.327532	0.328204
102764398	+0.216	3.623	5.401	0.529083	0.314593	0.168507	0.388917
102773399	–0.244	2.606	2.606	0.502402	0.609873	0.188159	0.104685
102794063	–0.260	3.863	3.863	0.615920	0.613206	0.099535	0.104410
102806409	–0.276	3.894	3.849	0.502250	0.505260	0.188210	0.185990
102940723	+0.220	4.488	5.419	0.364129	0.407964	0.280646	0.254073
102961901	–0.216	3.709	3.709	0.617404	0.621043	0.098450	0.097288

computed the eccentricity and longitude of the periastron. The final fit for each star is displayed in Figs. 1 and 2, which shows the phase diagrams represented by black points, namely the normalized flux versus phase for all the stars of the present working sample. In these figures the red line represents the PHOEBE model. From the analysis of the light curve we can obtain the following quantities: Period (P), temperature ratio T_1/T_2 , inclination i , Kopal's modified potentials Ω_1 and Ω_2 and radii ratio R_1/R_2 . All these values are also listed in Tables 2 and 3, including a phase shift (Phsh) of the primary eclipsing.

To check the reliability of the present procedure, we computed the physical parameters from the CoRoT light curve of HD 50846 (Desmet et al., 2010). All the values obtained by these authors are reproduced in our procedure. The phase diagram for this binary system is displayed in Fig. 1.

3. Discussion and conclusions

We analyzed light curves of 10 eclipsing binaries identified in the scope of the CoRoT Space Mission. In addition to the orbital period, we computed the possible photometric solution for each eclipsing binary system. In these systems the temperature, luminosity and radius of the primary component are higher than the values obtained for the secondary, except for ID 102738809, where the secondary radius is higher than the primary. Of course, for a complete solution of each binary system, which includes the absolute determination of all parameters for each star and a full orbital solution, it is essential to combine photometric and spectroscopic informations. Nevertheless, one of the major goals of the present study is to alert the community to the large variety of binaries obtained from the CoRoT Space Mission data. For instance, one can observe from the phase diagram that our sample consists of several subtypes of binary systems such as the Algol type (ID 102673160, ID 102738809 and ID 102940723), Beta Lyrae type (ID 102764398,

Table 2

Light-curve parameters of the individual systems.

COROT ID	P	i	q	T_1/T_2	R_1/R_2	L_1/L_2
102622874	4.150	44.698	0.636	1.04	1.29	2.00
102673160	28.918	86.713	0.856	1.00	1.03	1.05
102738809	2.035	79.325	1.009	1.36	0.51	1.18
102750270	0.897	72.137	0.900	1.00	1.04	1.06
102764398	0.927	79.269	0.226	1.77	5.28	898.12
102773399	0.606	50.626	0.286	1.18	1.92	8.96
102794063	0.382	63.949	1.000	1.04	1.00	1.20
102806409	0.647	68.818	0.938	1.00	1.02	1.05
102940723	0.874	86.607	1.000	1.05	1.28	2.10
102961901	0.421	68.730	1.000	1.03	1.00	1.17

ID 102773399 and ID 102806409) and Wuma type (ID 102622874, ID 102750270, ID 102794063 and ID 102961901).

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