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LIGHT CURVE MODELING OF SHORT-PERIOD W UMa-TYPE STARS

PILECKI, B.[1,2]; STĘPIEŃ, K.[1]

[1] Warsaw University Observatory, Warsaw, Poland. e-mail: pilecki@astrouw.edu.pl; kst@astrouw.edu.pl

[2] Universidad de Concepción, Departamento de Astronomia, Casilla 160-C, Concepción, Chile.
e-mail: bpilecki@astro-udec.cl

We report the results of the curve modeling of a selected set of W UMa-type variables. They all belong to the low mass contact binaries (LMCB) which have orbital periods shorter than about 0.3 d, the total mass lower than about 1.4 M$\odot$ mass, moderate mass ratios and radii indicating that both components are on the main sequence (Stępień and Gazeas 2012). As a rule, they belong to W-type variables, where the more massive component is cooler than its companion. According to Rucinski (2007) LMCBs make a majority of all W UMa-type stars existing in the solar neighbourhood, yet the knowledge of their properties is very limited. Accurate values of the binary parameters, based on the precise photometric and spectroscopic observations, are known for a mere dozen LMCBs (Gazeas and Stępień 2008). The reason for the shortage of good data is, of course, the intrinsic faintness of these stars.

Evolutionary models of cool contact binaries have been obtained by Stępień (2006, 2011) under the assumption that they originate from detached binaries with the initial periods close to 2 d and angular momentum loss (AML) by the magnetized winds occurs during the whole evolution. The results indicate that LMCB are old MS objects with a characteristic age of 8-9 Gyr, but their lifetime in contact takes only about 10% of their total age. The orbit evolution of a contact binary is determined by the mass transfer from the presently less massive component to its companion and AML by the wind. In LMCBs the AML dominates, so the orbit contracts quickly and the binary overflows its outer critical surface, which leads to coalescence of both components. The mass ratio never reaches the extreme value of 0.1 or less.

All the variables presented in this paper have been discovered during the ASAS survey (Pojmański 2002). They were selected for the further investigation because they were bright and there were high quality, two-color light curves available for them. The light curve modeling of our stars was a part of a larger project (Pilecki 2009) in which almost 3000 stars were modeled using Monte Carlo approach and the Wilson-Devinney code (Wilson and Devinney 1971, 1973) in order to better undestand the nature of contact binaries in particular and the evolution of compact binaries in general.

In this project light curves for systems that exhibit period change were cleared from this influence, we also subtracted all long-term brightness variation. Both actions were necessary because of the long time span of collected data. To make analysis of this amount of stars feasible we have varied the smallest possible subset of parameters including temperature ratio, modified potentials of both components and inclination. The temperature

Table 1: The data for the new, short-period W UMa-type variables

ASAS design.	Ephemeris HJD(T_0)=2450000+	$V_{\rm app}$ mag	ΔV mag	$V-I$ mag	T_2 K	T_1/T_2	i deg	q
033959+0314.5	1920.623+0.282709$\times E$	11.33	0.87	0.99	4830	0.964 (12)	84.5 (1.4)	0.71
050837+0512.3	2496.963+0.266349$\times E$	11.06	0.66	1.09	4550	0.955 (16)	73.8 (1.2)	0.71
050852+0249.3	1952.830+0.295706$\times E$	11.25	0.7	0.95	4950	0.940 (12)	83.5 (4.3)	0.35
052452-2809.2	1868.922+0.275778$\times E$	10.61	0.37	0.76	5510	0.964 (20)	68.5 (1.4)	0.25
061531+1935.4	2621.829+0.287842$\times E$	11.06	0.59	0.83	5300	0.982 (16)	81.3 (4.7)	0.35
085710+1856.8	2622.863+0.291015$\times E$	11.23	0.61	0.91	5060	0.957 (15)	78.2 (2.1)	0.35
095048-6723.3	1869.068+0.276944$\times E$	11.13	0.74	1.12	4480	0.977 (09)	84.3 (3.0)	0.50
120036-3915.6	1871.020+0.292670$\times E$	10.45	0.5	0.90	5100	0.974 (09)	80.8 (1.9)	0.25
143751-3850.8	1903.125+0.292395$\times E$	11.35	0.79	1.14	4460	0.949 (12)	78.1 (1.5)	0.50
144243-7418.7	1903.86+0.294768$\times E$	8.25	0.45	0.77	5460	0.951 (11)	72.1 (1.2)	0.25
155227-5500.6	1926.952+0.297646$\times E$	11.45	0.33	0.93	5020	0.977 (35)	55.8 (5.4)	0.71
155906-6317.8	1920.924+0.266766$\times E$	10.47	0.71	1.03	4710	0.949 (07)	78.4 (0.8)	0.50
174655+0249.9	2159.601+0.299953$\times E$	9.57	0.25	0.95	4950	0.926 (30)	55.9 (1.8)	0.35
195350-5003.5	1874.706+0.286828$\times E$	11.44	0.95	1.10	4520	0.935 (10)	83.9 (1.2)	0.71
212915+1604.9	2754.934+0.282956$\times E$	11.33	0.61	1.03	4720	0.981 (12)	88.3 (3.6)	0.35

of the hotter component was based on the $V-I$ index and was set fixed. Keeping in mind that the photometric mass ratios are quite inaccurate (except for binaries with total eclipses) we have used a set of 12 predefined values spread logarithmically from 0.09 to 4.0 – the step in q-value roughly corresponding with the average accuracy that was expected for these data. The light curves were solved for this set and a best solution was then accepted.

Nevertheless we have crosschecked our values of q for about 50 stars with those already established in the literature and found that they seldom differ significantly for short-period compact systems presented here, which is rather expected as for such systems mass ratio manifests itself in the shapes of components and thus in the shapes of the light curves. This is not true for well resolved systems. Our results show also that the q-values are indeed concentrated around the value 0.5, the property noticed already by Rucinski (2010). Because of the performed Monte Carlo analysis we were able to determine values and their reliable errors for all the other parameters.

Table 1 presents the data for the investigated stars. The consecutive columns give ASAS designation (with the coordinates for 2000), ephemeris, apparent V magnitude, V-amplitude of the light curve, $V-I$ index, temperature of the hotter (but less massive) component, temperature ratio, orbit inclination i and mass ratio $q = M_1/M_2$. For the temperature ratio and the orbit inclination $1-\sigma$ errors in the last two digits are quoted in the parentheses.

Spectroscopic observations of these stars are urgently needed. They would permit calculations of the absolute parameters of the binaries and checking their values against model calculations. In particular, it will be possible to determine the progenitor binaries and evolutionary paths of LMCB.

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