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Binary systems at and beyond the short-period limit of WUMa systems

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Abstract.
The short-period limit of W UMa-type contact binaries of about 0.22 days is very sharp and well defined. Observations and investigations of close binaries beyond this limit can provide important information on the origin and evolutionary processes of contact binaries, as well as on the formation and migration history of low-mass stars. In the past several years, we have monitored some close binaries below the short-period limit by using several small telescopes and 2m-class telescopes. Photometric solutions and period changes of these binary stars were analyzed and investigated. Some new contact binaries below the limit were detected. Our results reveal that the rarity of contact binaries below the short-period limit could not be explained by rapid dynamical destruction.

Key words: Stars: binaries : close – Stars: binaries : eclipsing – Stars: low-mass

1. Introduction

Contact binaries below the short-period limit are very rare (e.g., Rucinski 1992; Becker et al. 2011). Up to now, only a few contact binaries below the limit have been discovered, e.g., GSC 0137-00475 with a period of 0.2178 (Rucinski & Pribulla 2008) and the red-dwarf contact binary SDSS J001641-000925 with a period of 0.1985615 days (Davenport et al. 2013). The rarity of contact binaries below the limit suggests that they are: 1. difficult to produce because the AML time-scale is much longer (e.g., Stepien 2006, 2011), 2. still very difficult to detect, or 3. so unstable that they are rapidly destroyed (e.g., Jiang et al. 2013).

Thanks to several surveys in the world (e.g., SDSS, WFCAM Transit Survey, and SuperWASP), some close binaries with periods below the limit ($P < 0.22$ days) have been discovered. Observations and investigations of close binaries beyond this limit can provide valuable information on the origin and evolution of contact binaries as well as on the formation and migration history of low-mass stars. In the past several years, we have monitored some close binaries below the short-period limit using several small telescopes and 2m-class telescopes. Photometric solutions and period changes of these binary stars were analyzed and investigated.

2. New contact binaries near and below the period limit

2.1. 07d_2_2291

07d_2_2291 was discovered by the Wide-Field Camera (WFCAM) Transit Survey as an EW-type close binary with an orbital period of 0.2013 days (Nefs et al. 2012). The first complete RI light curves were obtained in January 2013 using the Danish 1.54-m telescope at La Silla. Photometric solutions with the W-D method suggested that it is a shallow contact binary system ($f = 7.7\%$) with a mass ratio of $q = 0.42$. The observations and the theoretical light curves are shown in Fig. 1.

2.2. 07a_1_3517

07a_1_3517 is another EW-type binary with a period of 0.2143 days that was discovered by the WFCAM Transit Survey (Nefs et al. 2012). RI light curves were obtained in November 2012 using the 2.16-m telescope in China. Photometric solutions with the W-D method suggested that it is an A-subtype shallow contact binary system ($f = 9.3\%$). It is one of a few very short-period contact binaries with a low mass ratio of $q = 0.34$.

2.3. 1SWASP J052926.88+461147.5

1SWASP J052926.88+461147.5 was discovered by the SuperWASP photometric survey as a short-period close binary with a period of 0.22664218 days (e.g., Lohr et al. 2013). RI light curves were obtained in January 2013 using the 85-cm telescope in China. Photometric solutions were obtained with the W-D method. It is shown that it is an A-subtype contact binary system ($f = 20\%$) with a mass ratio of $q = 0.37$.

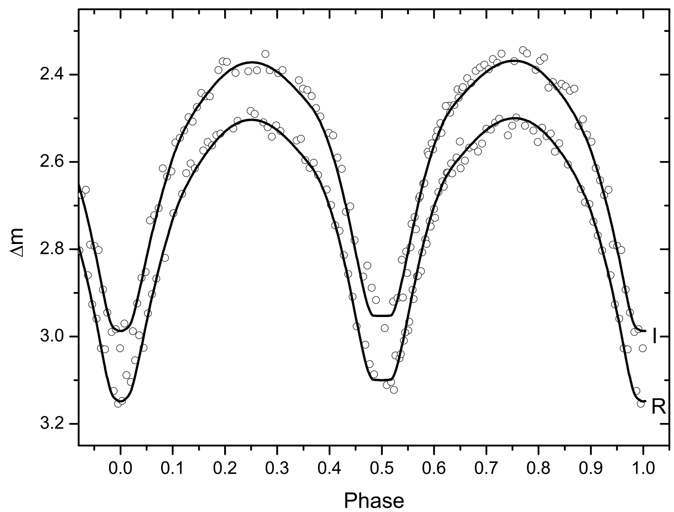

Figure 1. Observed and theoretical light curves of 07d_2_2291 in R and I bands.

3. Stability of red-dwarf contact binaries

SDSS J001641-000925 was discovered as a faint EW-type eclipsing binary by the SDSS survey (Becker et al. 2011) of spectral type M0-M1. It is a short-period system with a period below 0.2 days (0.1985615 days). Photometric and spectroscopic solutions suggest that it is a contact binary system with $M_1 = 0.58$ and $M_2 = 0.34\,M_\odot$ (Davenport et al. 2013). The authors pointed out that the orbital period is decreasing rapidly, which suggests that the system is dynamically unstable and undergoing active coalescence. These properties indicate that it is a key target to test the theories and to study the properties of red-dwarf contact binaries. By including our new data from several telescopes, we found that the rapid decrease in the orbital period is not true (see Fig. 2).

4. Discussions and conclusions

Based on our photometric solutions, three new contact binaries were detected below or near the short-period limit. We discovered that the rapid period decrease in SDSS J001641-000925 is not true. This result reveals that the short-period limit could not be explained by rapid dynamical destruction. It suggests that red-dwarf contact binaries are stable. The reason for the rarity of contact binaries below the short-period limit is that they are difficult to produce and/or

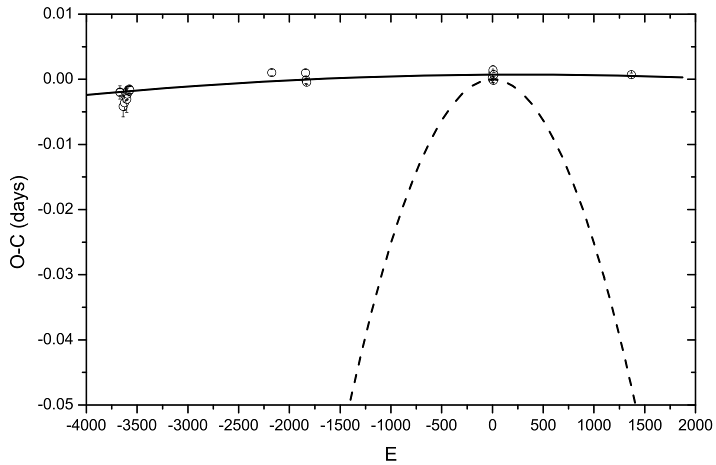

Figure 2. The O-C diagram of SDSS J001641-000925. The dashed line refers to the period decrease predicted by Davenport et al. (2013), while open circles are the observations.

are still very difficult to detect. Tertiary companions may play an important role for their formation and evolution (e.g., Qian et al. 2013).

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