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ASAS J071829-0336.7: SHORT-PERIOD END FOR CONTACT BINARIES REDEFINED

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It is well known that classical W UMa-type binaries have spectral types A-K and we do not observe a single system with components of M spectral type. The spectral types and colors correlate with orbital periods due to the main-sequence state of the components, which results in sharp cut-off in the number of systems at short orbital periods. The physical reasons for the observed period cut-off are still not clear (see Rucinski, 1992).

The statistical data on the contact binaries have significantly been improved by the The All Sky Automated Survey (ASAS) (Pojmanski 1997, 2004; Paczynski et al., 2006) by discovery of several hundred new systems in the magnitude range 8-13 magnitudes. Analysis of their period distribution (Rucinski, 2007) showed that the maximum in the contact-binary numbers occurs at about $P = 0.27$ days with definite short-period cut-off at about 0.215-0.22 days. Rucinski (2007) indicated seven contact-binary candidates with $P < 0.22$ days in the ASAS sample and selected GSC 1387-475 as the best candidate. The photometric and spectroscopic investigation of Rucinski & Pribulla (2008) confirmed that GSC 1387-475 is genuine contact binary; at present being record holder for field systems with $P = 0.2178$ days. The only known contact binary having shorter period is V34 in globular cluster 47 Tuc with $P = 0.2155$ days (Weldrake et al., 2004).

In our investigation we focused on two other ASAS candidates listed in Table 3 of Rucinski (2007) observable from northern mid-latitudes: J071829-0336.7 ($P_{ASAS} = 0.211249$ days, $V_{max} = 13.75$), and J113031-0101.9 ($P_{ASAS} = 0.213135$ days, $V_{max} = 13.36$). Both stars are fainter than $V = 13$ in the maximum, therefore useful spectroscopic observations leading to sound analysis would require 8-10m class telescope because of very short orbital periods. While 2MASS infrared color of J071829-0336.7, $(J - K) = 0.81$ (K7V) is consistent with extremely short orbital period, J113031-0101.9 is too blue, $(J - K) = 0.40$ (G4-5V), to be contact binary with the orbital period given in the ASAS database.

Both targets were observed at the Stará Lesná Observatory of the Astronomical Institute of Slovak Academy of Sciences using 50cm Newton telescope equipped with SBIG ST10MXE CCD camera (see Pribulla & Chochol, 2003). Expecting both objects to be mid K-type binaries the observations were performed in the R_C and I_C filters only. The instrumental magnitudes of the targets have been obtained by the aperture photometry using the photometrically calibrated frames (dark frame subtraction and flat field division). The differential magnitudes have been left in the instrumental photometric system, very close to the Johnson-Cousins system. The part of typical CCD frames in the I_C passband for either of the targets showing the variable, comparison and check stars are shown in Figs. 1-2. The times of minimum light for both systems determined using Kwee & van Woerden's method are listed in Table 1. The preliminary light-curve (LC) analysis has been performed using code *ROCHE* (see Pribulla, 2004).

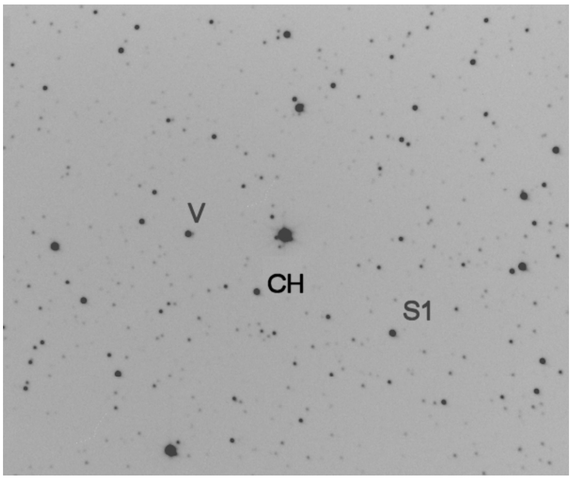

Figure 1. Field of the eclipsing binary ASAS J071829-0336.7. The size of the field is $11\overset{\prime}{.}20 \times 8\overset{\prime}{.}33$.

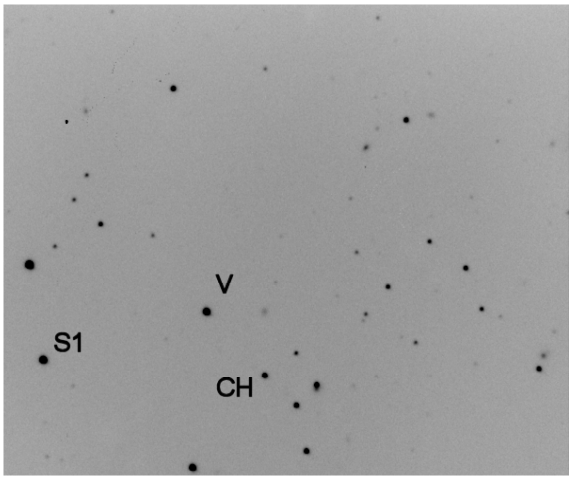

Figure 2. Field of the eclipsing binary ASAS J113031-0101.9. The size of the field is $11\overset{\prime}{.}20 \times 8\overset{\prime}{.}33$.

Table 1. Times of primary (I) and secondary (II) minima for both eclipsing binaries. Weighted averages from individual filters are given.

Star	HJD	Error	Filters	Type
J071829-0336.7	2454845.4267	0.0002	$(RI)_C$	I
	2454865.3905	0.0001	$(RI)_C$	II
	2454916.3039	0.0001	$(RI)_C$	II
J113031-0101.9	2454905.4210	0.0005	R_C	I
	2454917.4807	0.0002	$(RI)_C$	I

J071829-0336.7 Although this target has been observed during three nights (Jan 13/14, Feb 2/3 and Mar 25/26, 2009) only, thanks to the extremely short orbital period, full phase coverage has been achieved. The differential LC of J071829-0336.7 has been obtained with respect to USNO-A 0825.04506649 having similar color. The stability of this comparison has been checked using USNO-A 0825.04514810. Our new photometry (Fig. 3) definitely shows that the system is a close binary and not a pulsating variable. Very short orbital period given in the ASAS catalogue has been checked by fitting trigonometric polynomials of the 12th degree to the phase diagrams of our I_C data for test periods between 0.205 and 0.215 days. The best period was later optimized by non-linear least squares fitting of even trigonometric polynomials resulting in the following ephemeris for the primary minimum:

$$\mathrm{HJD\ (MinI)} = 2\,454\,874.7916(3) + 0.2112594(6)E, \qquad (1)$$

compatible with the ASAS result. When scrutinizing the CCD frames of the system a faint companion has been noticed west of the system which could not be separated during the aperture photometry, but which adds unknown amount of third light. The minima of the system are partial, therefore geometric parameters cannot reliably be determined without spectroscopic mass ratio. The observed LC could be solved successfully for a large range of mass ratios between 0.55 and 0.85 (limited by rather large photometric amplitude, about 0.55 mag). Assumption of the W-type classification (less massive component slightly hotter) always resulted in better χ^2. For the case of q=0.65, convective envelope, temperature of the hotter component 4020 K (K7V), marginal contact (fill-out = 0) the orbital inclination is $i = 76\overset{\circ}{.}8$. The system sets the new short-period limit for contact binaries.

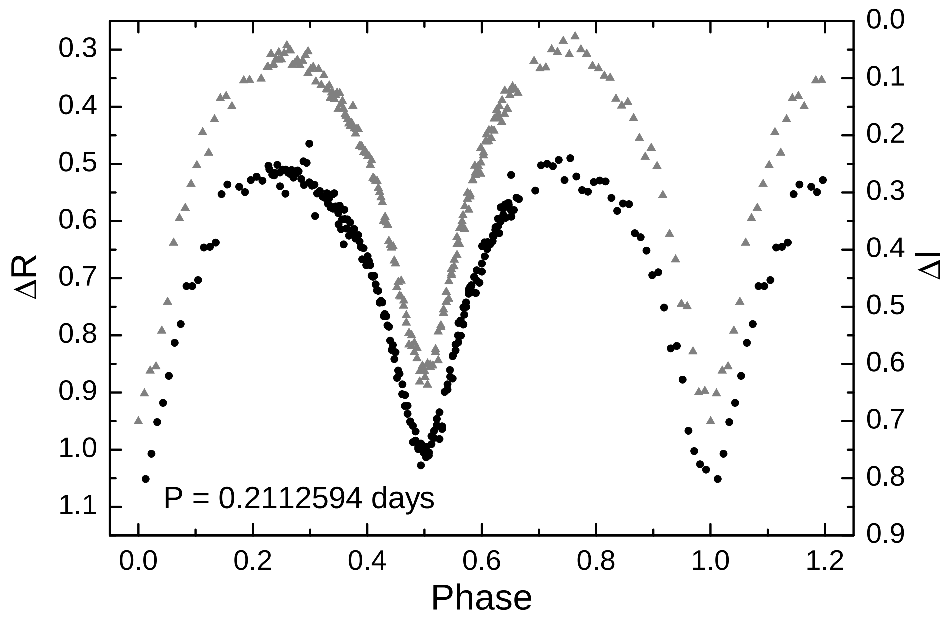

Figure 3. R_C (gray triangles) and I_C (black circles) LCs of J071829-0336.7.

J113031-0101.9 The LC of the variable (Fig. 4) has been obtained by aperture photometry with respect to GSC 4930-00167. The stability of the comparison has been checked using USNO-A 0825.07480282. The CCD photometry (Jan 25/26, Feb 2/3, Feb 29/Mar 1, Mar 14/15, 25/26, 26/27, 2009) showed that the orbital period given in the ASAS catalogue, $P_{ASAS} = 0.213135$ days, is spurious. This became evident from the observing run on March 14/15 which covered both minima and indicated orbital period substantially longer, being about 0.270 days. Unfortunately, ASAS photometry is too noisy to reliably determine/improve the orbital period. Therefore, the orbital period has been searched by fitting trigonometric polynomials of the 12th degree to the phase diagrams of our I_C data for test periods between 0.25 and 0.29 days. The best period was later optimized by non-linear least squares fitting of even trigonometric polynomials resulting in the following ephemeris for the minimum:

$$\mathrm{HJD(MinI)} = 2\,454\,905.2867(3) + 0.270969(4)E. \qquad (2)$$

The Stará Lesná data (Fig. 4) show that the system is totally eclipsing, but otherwise rather usual contact binary. Thanks to the total eclipses the geometric parameters, $q = 0.15$, $i = 88^\circ$, and fill-out $f = 0.5$ are rather reliable (unless there was third light). The system, however, requires photometric observations from at least 1m telescope.

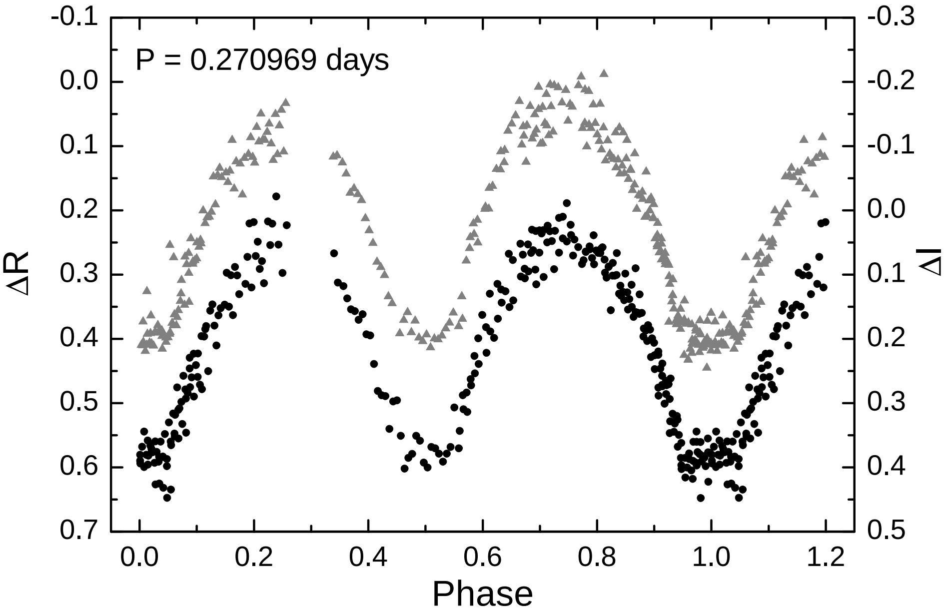

Figure 4. $(RI)_C$ light curves of J113031-0101.9. The centered symbols as in Fig. 3.

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