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ASAS 000709+2621.5 IS AN OVERCONTACT ECLIPSING BINARY, NOT A δ Sct VARIABLE

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Recently the discovery of new variable stars has been accelerating due to large observing programs such as ROTSE, MACHO, ASAS, OGLE, etc. However the low precision of these data as well as their automatic reduction and fitting led to the wrong classification of many targets. This refers especially to the cases of almost sinusoidal light curves which are appropriate both for δ Sct variables and for W UMa systems. Their right classification often requires follow-up observations and analysis.

The star ASAS 000709+2621.5 (further shortly ASAS 0007) is such a case. It was classified as a δ Sct variable with a pulsation period of P=0.2017 d and amplitude of 0.49 mag on the base of the ASAS data (Pojmanski 2000). We built folded curves of these data with periods $1P$ and $2P$ (Fig. 1) but they did not allow us to conclude if the target is a δ Sct variable or a W UMa binary.

To answer this question we carried out follow-up photometric observations of ASAS 0007 with the 60-cm Cassegrain telescope using the FLI PL09000 CCD camera (3056 × 3056 pixels, 12 μm/pixel, field of view 27.0×27.0 arcmin with focal reducer) of the Rozhen National Astronomical Observatory (Table 1). The average photometric precision per data point was below 0.01 mag.

Table 1. Journal of the Rozhen observations

Date	exposures (s)	filters	number
Aug 20 2010	60, 60	V, I	120, 120
Aug 22 2010	60, 60	V, I	176, 177
Aug 23 2010	60, 60	V, I	16, 16
Sept 17 2010	70	I	420

Table 2. Coordinates, magnitudes and colors of the target and standard stars

Star	GSC1ID	RA (2000)	DEC (2000)	V	$V-I$
ASAS 0007	0173200262	00 07 09.00	+26 21 30.0	11.55	0.86
C1	0173200564	00 07 24.71	+26 16 38.1	12.87	1.20
C2	0173201665	00 07 15.61	+26 23 33.1	11.10	1.25
C3	0173200140	00 07 10.20	+26 15 49.9	14.14	1.25

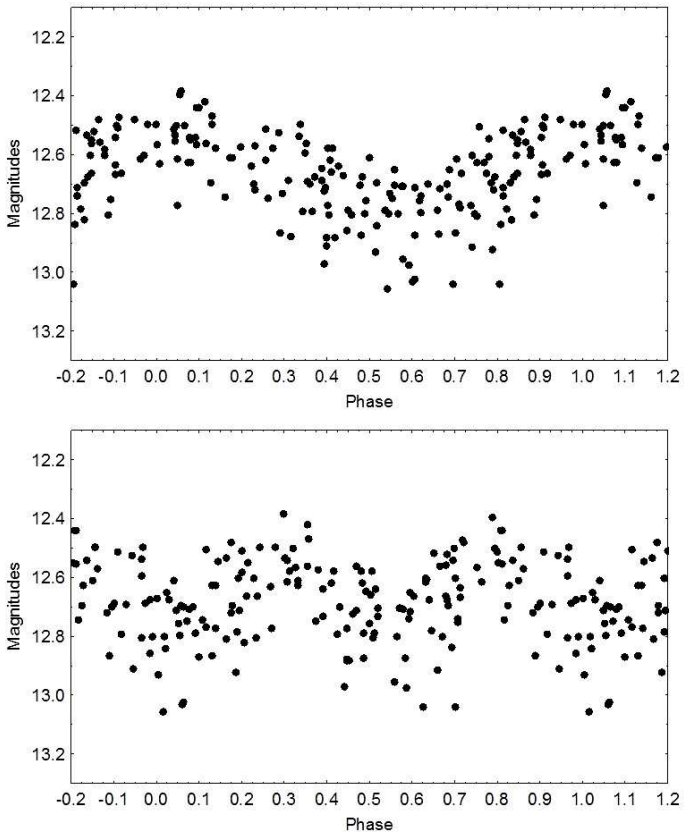

Figure 1. Folded light curves of the ASAS data with periods $1P$ (top) and $2P$ (down)

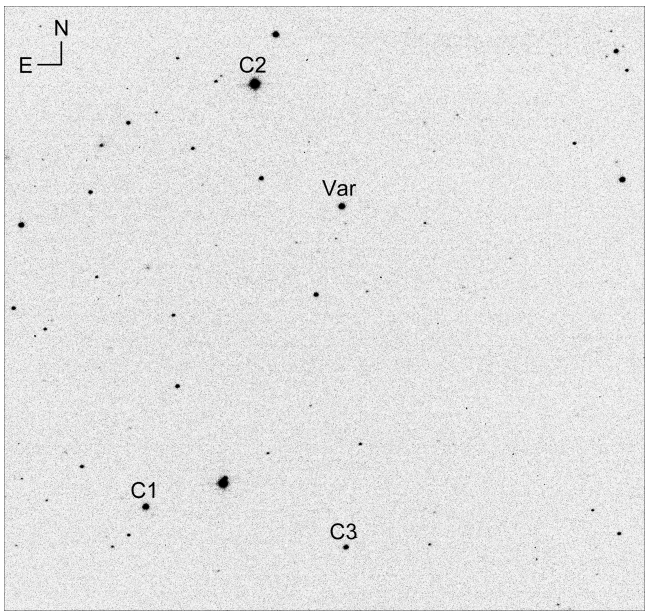

Figure 2. The field 10×10 arcmin around ASAS 0007

The standard procedures were used for reduction of the photometric data. The standard stars in the observed field (Fig. 2) were chosen by the criterion to be constant within 0.01 mag during the observations in all filters and all nights. Table 2 presents their V magnitudes and $V-I$ colors from USNO-B1 catalog.

The periodogram analysis of our I data (which are considerably more numerous than the V data, see Table 1) with a software PERSEA led to the ephemeris

$$\mathrm{HJD(MinI)} = 2455429.744 + 0.4034 \times E \qquad (1)$$

and Figure 3 presents the corresponding folded light curves of ASAS 0007.

The amplitudes of the light variability in V and I filters are correspondingly 0.32 mag and 0.30 mag. The previous bigger V amplitude of 0.49 mag (Pojmanski 2000) probably due to the rough automate reduction of the ASAS data.

The qualitative analysis of the Rozhen data revealed binary nature of ASAS 0007 rather than δ Sct variability due to the following reasons:

(a) There are two light minima with different depths (visible in I filter);

(b) The brightness minima seem slightly sharper than the maxima;

(c) We calculated the de-reddened color index $(V-I)_0$=0.86 of the target by the Galactic Reddening and Extinction Calculator (Schlafly & Finkbeiner 2011). It corresponds to temperature T_m=5870 K according to the tables of VandenBerg & Clem (2003). This value is quite low for a δ Sct star (see Table 2 and Figure 2 of McNamara 2000) but appropriate for a W UMa star.

Another important criterion for the binary nature of ASAS 0007 could be the successful reproducing of its light curve by eclipses. That is why we tried to model the Rozhen data of ASAS 0007 using the code PHOEBE (Prša & Zwitter 2005) by the following procedure.

Initially the primary temperature was fixed as T_1=T_m. We adopted coefficients of gravity brightening 0.32 and reflection 0.5 appropriate for late stars while the limb-darkening coefficients for each component were taken from the tables of VanHamme (1993) according to its temperature. The fitted parameters were: secondary temperature T_2, mass ratio q, orbital inclination i and potentials $\Omega_{1,2}$ (and correspondingly relative radii $r_{1,2}$ and fillout factors $f_{1,2}$). Finally we varied the temperatures of the two components around T_m to reach a best fit of the observations.

The parameter values corresponding to our light curve solution are: orbital inclination $i = 61\overset{\circ}{.}30 \pm 0\overset{\circ}{.}06$; mass ratio $q = 0.953 \pm 0.003$; temperatures $T_1 = 5940 \pm 113$ K and $T_2 = 5673 \pm 105$ K; relative radii $r_1^{\mathrm{mean}} = 0.395 \pm 0.005$ and $r_2^{\mathrm{mean}} = 0.386 \pm 0.005$ (potentials $\Omega_1 = \Omega_2 = 3.595 \pm 0.007$); relative luminosities $l_1 = 0.55$ and $l_2 = 0.45$. The cited values of the parameter errors are the formal ones obtained by PHOEBE.

The synthetic curves corresponding to these parameters (Fig. 3) revealed that the Rozhen data can be well-reproduced by partial eclipses of an overcontact binary (with fillout factor $f_{1,2}$=0.147) whose components are not in thermal contact. Hence, the analysis of our observations of ASAS 0007 allowed us confidently to conclude that it is an eclipsing star but not a δ Sct variable, as it was previously classified.

This investigation is a new emphatic illustration of the proposition that the morphological classifications given in large data sets, especially for variable stars with almost sinusoidal light variability, might be wrong. Hence, the results of the statistical investigations on the base of such classifications should be assumed rather as approximate estimations.

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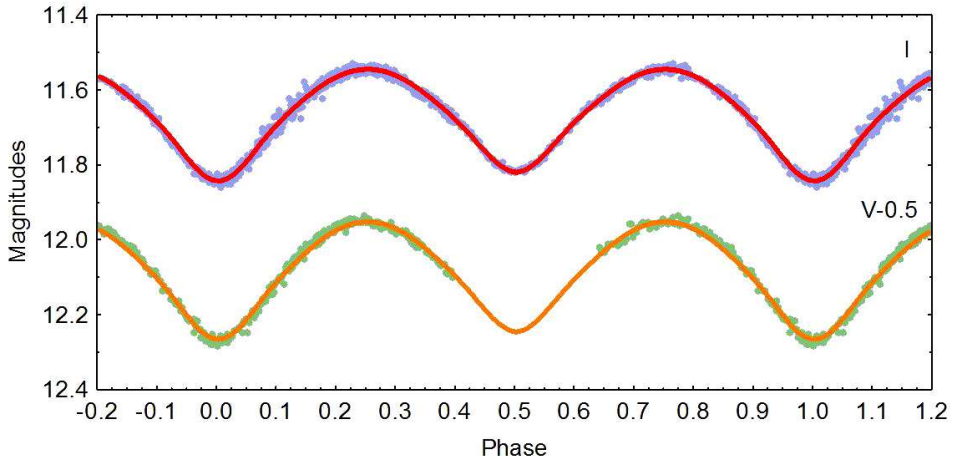

Figure 3. Rozhen VI folded light curves of ASAS 0007

bourg, France, USNO-B1.0 catalogue (`http://www.nofs.navy.mil/data/fchpix/`), and NASA's Astrophysics Data System Abstract Service.

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