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DISCOVERY OF A NEW PERIODIC VARIABLE STAR CzeV503

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The field of the semi-regular variable KU Her (Hoffmeister 1935; Sipahi 2012) and the anomalous Cepheid in eclipsing binary system ASAS J182611+1212.6 (Pojmanski 2002; Antipin, Sokolovsky & Ignatieva 2007) was monitored during three months from June 2013 to September 2013 (see a journal of observations in Table 1). We performed Strömgren *vby* photometry at the Observatory and Planetarium in Brno using 14" Celestron CGE 1400 XLT telescope equipped with a G2-4000 CCD camera (2056×2062 KAI-4022 chip). As the observed stars are long-period variables, typically five frames in each passband with exposure times of 40 to 80 s were gathered per night. We combined the images collected in each night into one single frame (one frame for each passband) to achieve better signal-to-noise ratio. Subsequently, we searched for new long-term variables.

Our effort was rewarded by the identification of CzeV503[1] = USNO-A2 0975-11593384 as a new variable with an amplitude of light changes of about 0.2 mag in y. Although the variability of the star was also noticeable in other two passbands (v, b), these data were inappropriate for further analysis.

All frames were calibrated in the standard way (dark frames and flat fields). The aperture photometry, as well as the reduction, was done using C-Munipack software[2] (Motl 2009) which is based on DAOPHOT (Stetson 1987). USNO-A2 0975-11599404 and USNO-A2 0975-11604298 were used as comparison and check star, respectively.

Despite a three-month monitoring, our data[3] were insufficient for period determination. Fortunately, data of the variable were found in NSVS (Woźniak et al. 2004, unfiltered measurements) and in ASAS-3 (Pojmanski 2002, V band). ASAS data were unusable due to the low number of points (only 29 measurements) and high scatter (the star is too faint for ASAS, 14.7(6) mag). NSVS gathered 176 measurements with brightness 12.9(1) mag and the data showed periodic variations with similar amplitude as our y data. Therefore we stitched them together by simple linear fitting. Such combined dataset was used for period analysis.

We used the Period04 software (Lenz & Breger 2005) and found two probable periods of about 60 d and 120 d. Light variations $m(t)$ were fitted by non-linear least-squares

[1]star included in Czech catalogue of discovered variable stars http://var.astro.cz/newvar.php
[2]http://c-munipack.sourceforge.net/
[3]available online at the IBVS website.

Table 1: Journal of observations. N is the number of combined images.

Night	Start UTC	Exp. [s]	N	Night	Start UTC	Exp. [s]	N
20 June 2013	01:20	60	4	2 August 2013	20:51	80	8
1 July	01:07	40	5	3 August	19:51	80	6
2 July	01:31	40	7	5 August	19:53	80	6
4 July	01:02	40	6	6 August	19:56	80	5
6 July	22:45	40	11	7 August	19:53	80	4
9 July	23:56	40	10	8 August	21:49	80	5
15 July	01:19	40	7	11 August	19:49	80	4
16 July	01:24	40	8	12 August	19:46	80	3
17 July	21:05/1:46	80	5/8	30 August	20:58	80	5
18 July	20:25	80	2	6 September	20:24	80	10
19 July	01:18	40	6	17 September	21:16	80	4
21 July	23:43	80	6	30 September	19:37	80	6
30 July	20:16	80	5				

method, where the main function was selected as a second-order harmonic polynomial ($n = 2$)

$$m(t) = m_0 + \sum_{i=1}^{n} m_i \cos\left(2\, i\, \pi\, \frac{t - E_0}{P}\right), \tag{1}$$

without the often used phase terms (data accuracy is low for finding other free parameters). Time t is in HJD, E_0 is the zero epoch and P is period in days in equation (1). The uncertainty of parameters E_0, P was determined by bootstrap method. The shorter period probably corresponds to a pulsating variable (Fig. 1). The times of maximum light can be expressed as:

$$T_{\max} = 2451308.9(6) + 60.58(2)^{\mathrm{d}} \cdot E \tag{2}$$

According to measurements taken from Zacharias et al. (2004) $m_B = 15.890$ and $m_V = 14.330$ and infrared 2MASS magnitudes $m_J = 9.056(22)$, $m_H = 8.109(25)$ and $m_K = 7.714(23)$ (Cutri et al. 2003), the star is very cool. This can explain also the big difference between ASAS-3 and NSVS magnitudes. ASAS-3 contains measurements in the standard V-band (Pojmanski 2002) $\sim$ (500–600) nm and therefore CzeV503 is fainter than in NSVS that used unfiltered CCD cameras sensitive in range from 450 to 1000 nm (Woźniak et al. 2004) and thus also in infrared band where is CzeV503 brighter than in visual band. Assuming the cool nature of the object, together with the period close to 60 d and low light variations (0.2 mag), we excluded cepheids, which are bluer and of larger amplitudes, as a possible explanation for the variations. Therefore, if 60-day period is the right one, we guess that this star is either a pulsating red giant or a semi-regular giant star.

If the longer period is real (Fig. 2), we assume CzeV503 to be a rotating ellipsoidal variable (non-eclipsing binary; see e.g. Soszynski et al. 2004; Nicholls, Wood & Cioni 2010). The time of minimum can be calculated from the following ephemeris:

$$T_{\min} = 2451399.8(7) + 119.75(4)^{\mathrm{d}} \cdot E. \tag{3}$$

In any case, further observations are needed to solve the problem of the nature of variability of this object.

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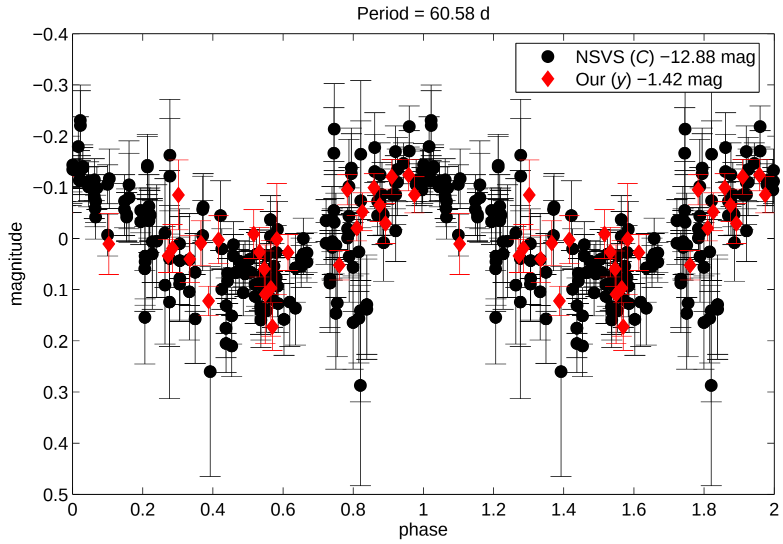

Figure 1. Our data together with data from NSVS database phased according to eq. (2).

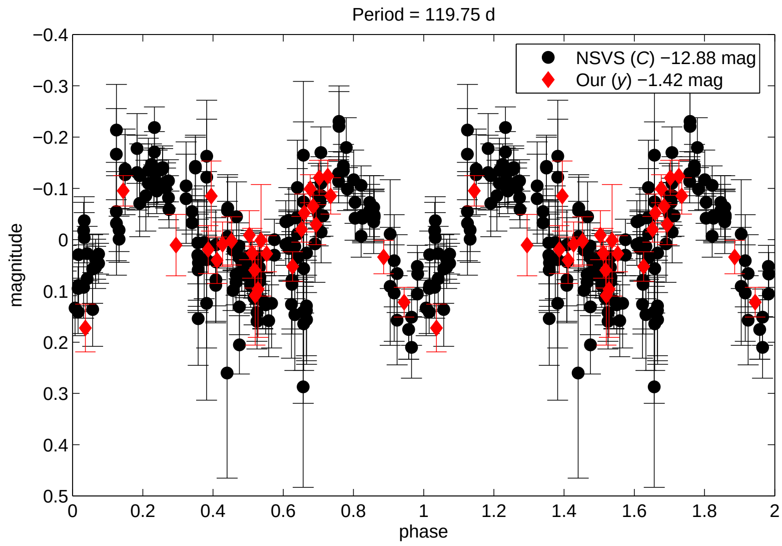

Figure 2. Data folded with the elements given in eq. (3).

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