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A NEW W UMA ECLIPSING BINARY NEAR V2553 Oph

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Abstract: The new variable star CzeV388 Oph = GSC 1003-2303 = USNO-B1.0 1037-0272001 has been discovered near V2553 Oph by means of CCD photometry. Based on shape of the light curve, amplitude and period (P = 0^d.397663) it is a W UMa type eclipsing binary. Five timings of primary and secondary minima were obtained. We have registered this star in VSX (Variable Star Index, AAVSO), and this star was named VSX J172448.6+134706.

1. Introduction

The new variable star CzeV388 Oph = GSC 1003-2303 = USNO-B1.0 1037-0272001 has been found in the field of V2553 Oph eclipsing binary during CCD photometric session 27th April 2012 at Observatory and Planetarium of Johann Palisa (Ostrava, Czech Republic). The new variable star is located at R.A. = 17h 24m 48.67s , DEC = +13° 47' 06.9" , based on USNO-B1.0 catalog. We have discovered the variability of GSC 1003-2303 using the software package *C-Munipack* (Motl, 2007) by the function – "Find variables". We have preliminary registered our new variable star in the Czech Variable star catalog (CzeV388 Oph) and in VSX catalog operated by AAVSO (VSX J172448.6+134706). In this paper, we present the basic elements of new variable star (initial epoch and period), 5 timing of minima and the phase curve.

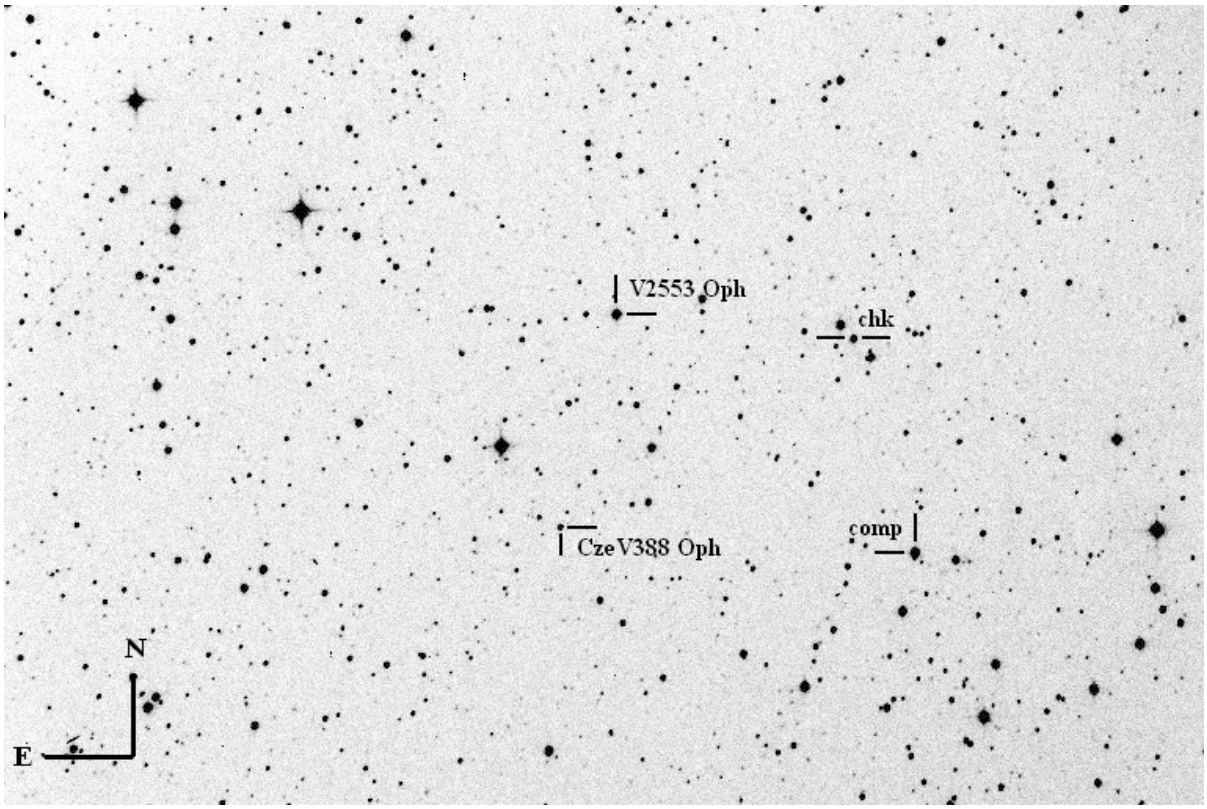

Figure 1. Chart of the vicinity of V2553 Oph, new variable star CzeV388 Oph = GSC 1003-2303 and both comparison stars *comp* and *chk* are marked. The field of view is 39.4'x26.3'.

2. Instrumentation, photometric sessions and methodology

All observations have been obtained using a 200 mm f/6 Newton telescope of Observatory and Planetarium of Johann Palisa and SBIG-ST8XME CCD camera with a camera sensor area of 1530x1020 square pixels (pixel linear dimension is 9 μm). This configuration results in a field of view (FOV) of 39.4'x26.3' (1.545 arcsec/px). The CCD was configured in a 2x2 binning mode resulting in angular resolution of 3.09 arcsec/px.

Most of the frames have been taken with Clear filter but last data set has been taken with Rc band filter for determining Rc magnitudes of new variable. Exposure time range is 60s – 90s depending on weather conditions. We observed CzeV388 Oph during 8 nights from 29th April to 18th July 2012 (see Table 1). We have obtained a total of 1512 CCD frames of new variable CzeV388 Oph, after deletions of bad measurements its 1014 data points. All of these data have been used for following analysis. All frames have been reduced using the software package *C-Munipack*. All frames have been calibrated by dark frame and flat-field corrections. Differential aperture photometry has been also performed in *C-Munipack*. Comparison stars are *comp* GSC 1003-0560 and *chk* GSC 1003-0301 (see Table 2). The Rc magnitudes have been calibrated using the method described by Dimock and Miles, 2009 which used r' magnitudes and (J-K) color indexes of reference stars from CMC14 and 2MASS catalogs. The positions of comparison stars as well as the position of new variable near V2553 Oph are marked on Figure 1.

Dates of the observations (yyyy-mm-dd)	Time (UT)	N of images	t_{exp} (s)	Filters used
2012-04-29	21:22 - 02:20	192	90	Clear
2012-04-30	21:34 - 01:57	189	60	Clear
2012-05-10	20:26 - 01:03	194	90	Clear
2012-05-25	20:04 - 23:39	68	90	Clear
2012-06-16	22:18 - 01:05	69	90	Clear
2012-06-26	20:10 - 00:56	92	90	Clear
2012-06-30	22:09 - 00:47	113	60	Clear
2012-07-18	19:50 - 23:30	97	90	Rc

Table 1. Summary of the observations: Date, time interval of photometric sessions, number images applied for analysis, exposure times and used filters.

Comparison	Catalogue ID	RA (hh:mm:ss.ss)	Dec (±dd:mm:ss.ss)	V (*) (mag)	Rc(*) (mag)
comp	GSC 1003-0560 USNO-B1.0 1037-0271605 CMC14 172401.8+134624	17:24:01.84	+13:46:22.5	11.60	10.99
chk	GSC 1003-0301 USNO-B1.0 1038-0270352 CMC14 172410.1+135315	17:24:10.19	+13:53:15.1	13.10	12.36

Table 2. Comparison stars used for differential photometry: Catalog names, position and brightness in the Rc and V bands.

(*) The Rc and V standard magnitudes of comparison stars have been calculated from its r' magnitude from CMC14 catalog and (J-K) color index from 2MASS catalog (Dymock and Miles, 2009).

3. Data analysis and result

The times of minima have been determined using the polynomial fit algorithm in the *Peranso 2.5* (Vanmunster, 2007) software. We have tried to use algebraic polynomials from third to six degree. But only polynomials of fourth and fifth degree fit well the minima. However, the curve fitting with other polynomials gave very similar timing of minima - within the intervals of uncertainties. 2 primary minima (I) and 3 secondary minima (II) were observed during April 2012 – July 2012 (see Table 3). First primary minimum is marked as Initial Epoch.

EPOCH	HJD	Error	Type	Filter
0	2456047.5041	0.0030	I	Clear
2.5	2456048.5009	0.0022	II	Clear
27.5	2456058.4426	0.0034	II	Clear
145.5	2456105.3658	0.0029	II	Clear
201	2456127.4343	0.0031	I	Rc

Table 3. Timing and type of minima of CzeV388 Oph**.**

To determine the approximate values of the period, the software *PerSea 2.6* (Maciejewski, 2007) and *Peranso 2.5* were used. The period has been determined from periodogram analysis using the ANOVA algorithm (Schwarzenberg-Czerny, 1996) implemented in *Peranso 2.5*. The periodogram is shown on the Figure 2.

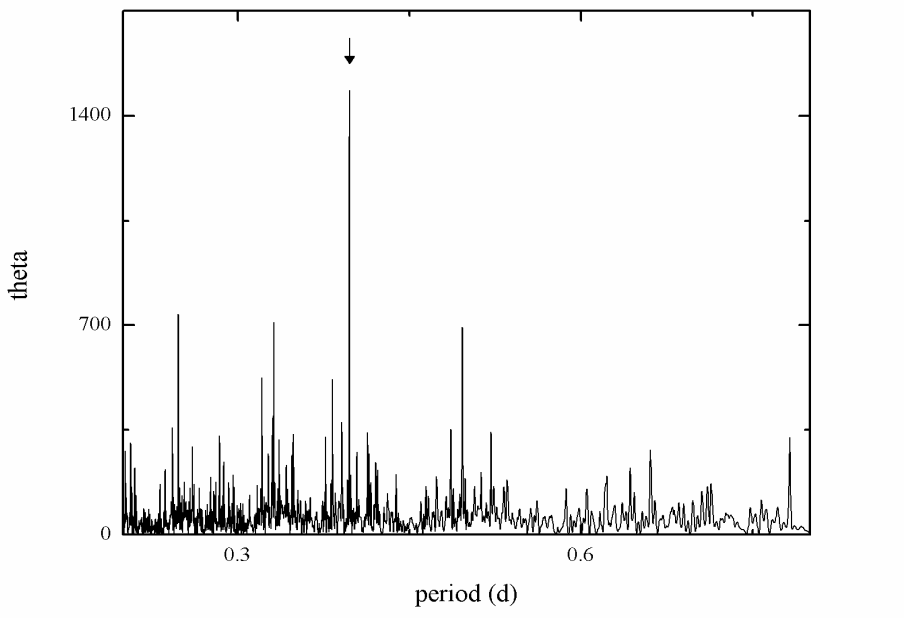

Figure 2. Periodogram of CzeV388 Oph, given by ANOVA period analysis.

We have used the ephemeris from *PerSea 2.6* analysis to create O-C diagram for all primary and secondary minima. This O-C diagram has been used to refine the period by weighted linear regression using *Stagraphics Plus 3.0* software. The following ephemerides have been determined:

$$HJD_{MinI} = 2456047.5061 + 0.397663 \times E$$
$$\pm 0.0007 \pm 0.000008$$

The O-C diagram for all primary and secondary minima, constructed with final ephemerides, is plotted in the Figure 3 with corresponding error bars.

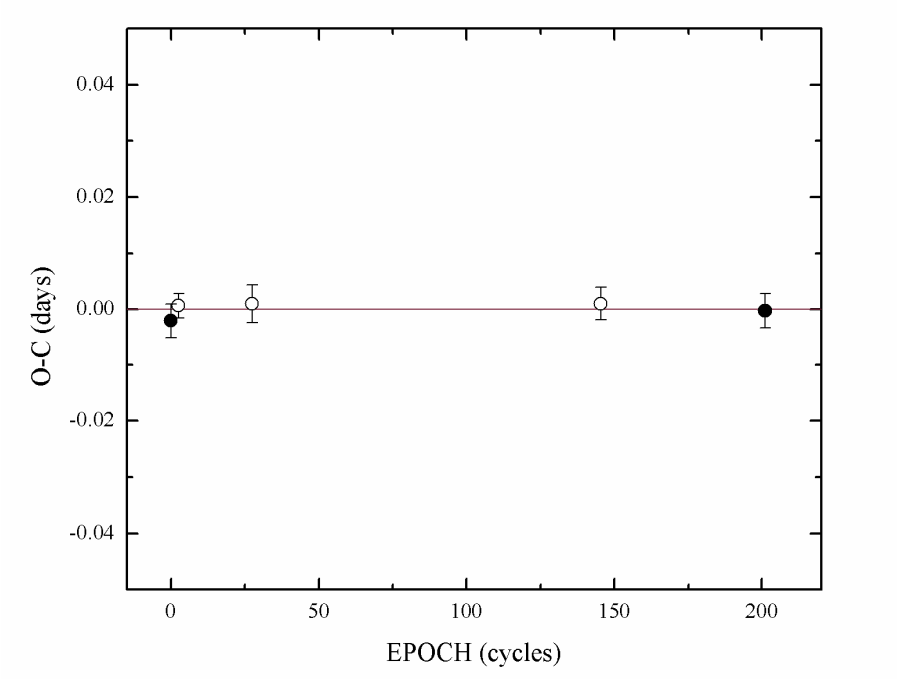

Figure 3. The O-C diagram for all observed primary and secondary minima.

We have used the polynomial fit algorithm implemented in *Peranso 2.5* to estimate the magnitudes of CzeV388 Oph primary minimum (Min I) and maximum (Max) in Rc band. The polynomial of fourth degree was used. Polynomial fit last data set show Min I magnitude as 13.94 mag and Max magnitude in the instrumental system as 13.61 mag. We have no measurements of any secondary minima in Rc band. That is why we could not derive the Min II magnitude of CzeV388 Oph directly. However, the maximum quantum efficiency of the camera sensor is on ~635 nm, which is close to the standard Rc-band. Then we may to roughly deduce the Min II magnitude from our Clear filtered measurements as ~13.8 mag.

There is phase curve of CzeV388 Oph, presented in instrumental differential magnitudes, in the Figure 4. Data sets from 29. 4., 26. 6. and 18. 7. exhibited strange O'Connell like vertical shift at the 0.75 phase, but this effect wasn't observed in other data sets. Recent study (Beaky et Koju, 2012) revealed that in most cases the size of the O'Connell effect changes over time scales of week or month. But we believe that the vertical shifts are caused by the Clear filter which is sensitive to changes of sky brightness because of light pollution from the city. More precise analysis with better photometric data is needed.

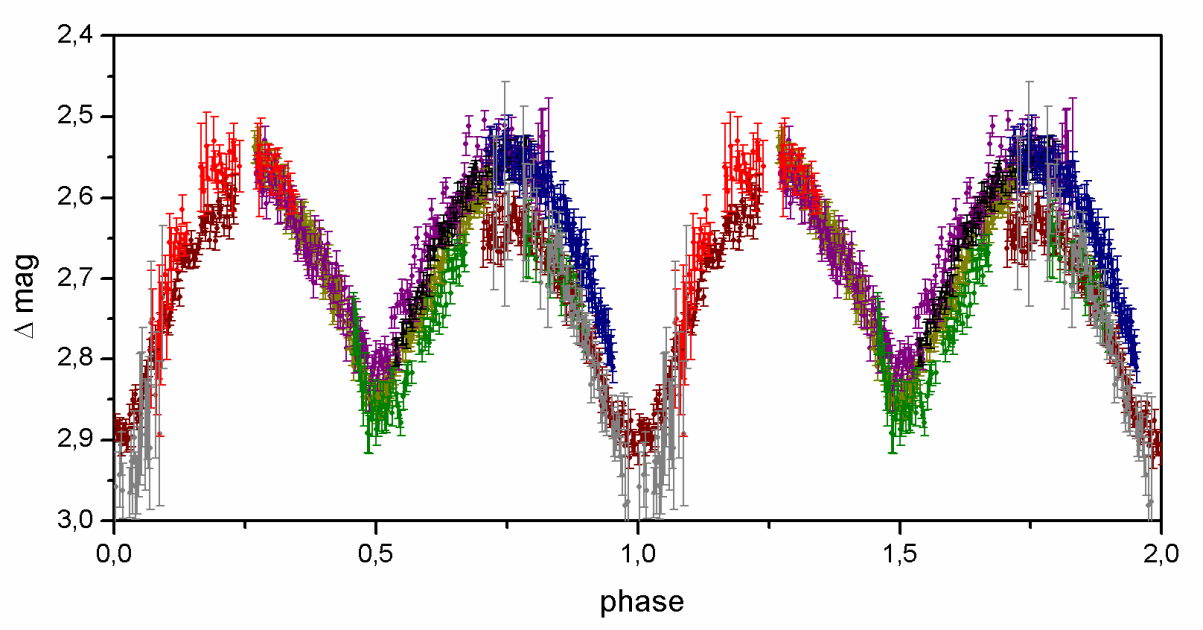

Figure4. Phase curve for CzeV388 Oph. The magnitudes are differential magnitudes with respect to the *comp* star (GSC 1003-0560). Different colors means different nights.

The shape of light curve, maximum amplitude 0.33 mag and the period $0^d.397663$ implies that CzeV388 Oph is a W UMa type eclipsing binary; based on GCVS phenomenological classification (Samus et al. 2011). All photometric parameters are summarized in Table 4.

Name	Type	Period (d)	Initial epoch (HJD)	Max (mag)	Min I (mag)	Min II (mag)
CzeV388 Oph	EW	0.397663 ± 0.000008	2456047.5061 ± 0.0007	13.61	13.94	~13.8

Table 4. Main characteristics of discovered star, needed for the GCVS. The magnitudes are in Rc-band.

4. Acknowledgments

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