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A NEW DELTA SCUTI VARIABLE CzeV616 CYG

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Abstract: A discovery of a new variable star in Cygnus is presented. In one night we witnessed subtle light changes of a star close to V1792 Cyg, which was previously thought to be stable. Data from NSVS and SuperWASP surveys were utilized to determine its type of variability and period estimation. It was found that the new variable CzeV616 Cyg, as the object is now designated, is a multiperiodic star of δ Sct type.

During unfiltered observation of the eclipsing binary V1792 Cyg in the night 22/23 July 2014 the nearby star TYC 3167-958-1 (RA $20^{h}52^{m}30^{s}.8935$, DEC+38°16′27″.20) appeared to be a new variable (see Fig. 1). It became designation CzeV616 Cyg in the catalogue of new variable stars, which have been discovered by Czech observers (Brat, 2006)[1]. Exposures with 60 s were acquired with telephoto lens F 200/3.5 equipped with CCD camera ATIK 320E (chip SONY ICX274AL, resolution 1620×1220 pixels) installed at CG-4 mount. Differential aperture photometry, as well as Dark Frame and Flat field corrections were performed using C-MuniPack package (Motl, 2009), which is based on DAOPHOT (Stetson, 1987). TYC 3167-256-1 and TYC 3167-932-1 were used as comparison and check star, respectively.

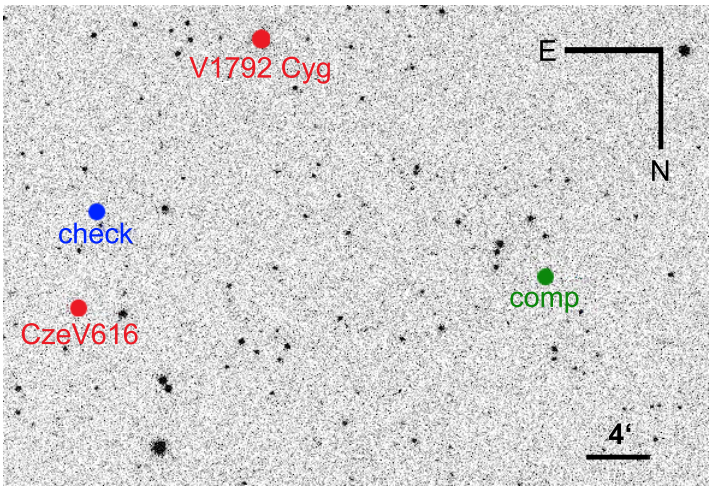

Figure 1: The detail of our CCD frame showing close vicinity of CzeV616 Cyg with identification of the stars.

Since we captured only a small part of the light changes (Fig. 2), we were neither able to decide about the type of variability, nor to determine the period just on the basis of our measurements. Therefore we searched for additional information about the star in literature and public archives.

[1] http://var2.astro.cz/czev.php

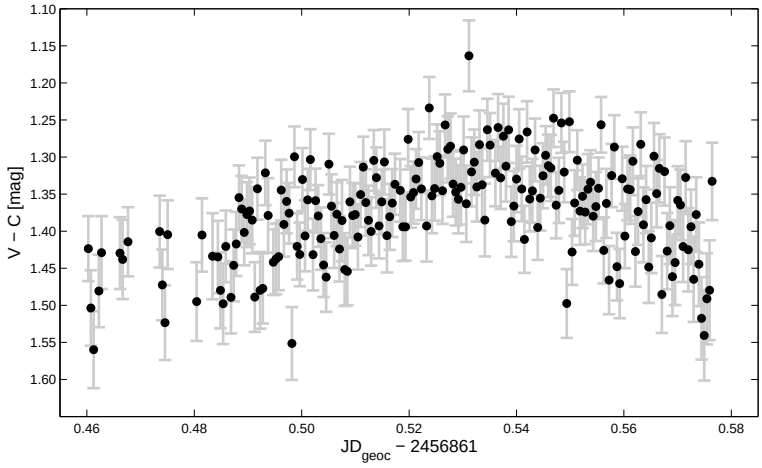

Figure 2: Light curve from the night 22/23 July 2014, 23:02-01:50 UTC

Observation from Hipparcos satellite provide $B - V = 0.441(134)$ mag (ESA, 1997). This value is consistent with spectral type wF5V (Ofek, 2008), and with temperature 6587^{+105}_{-113} K (Pickles & Depagne, 2010). Data from NSVS (Woźniak et al., 2004) and SuperWASP surveys (Butters et al., 2010) allowed us to perform period analysis, and to classify CzeV616 Cyg as a multiperiodic pulsating star of δ Sct type. The times of maxima, based on the strongest found frequency, can be expressed as

$$T_{\max} = 2454280.535(1) + 0.126475(1)\,\mathrm{d} \cdot E. \quad (1)$$

As a tool for period analysis we used Period04 (Lenz & Breger, 2005). NSVS data contained only 227 points in 242 days. Fourier amplitude spectrum of these data showed three significant frequencies. The first of them, $f_1^{\mathrm{NSVS}} = 20.047\,\mathrm{d}^{-1}$ is probably an instrumental artefact with unclear interpretation. The other two frequencies ($f_2^{\mathrm{NSVS}} = 7.9071(3)\,\mathrm{d}^{-1}$ and $f_3^{\mathrm{NSVS}} = 7.6970(4)\,\mathrm{d}^{-1}$) were identified also in SuperWASP data, which were of much better quality for period analysis (3154 points in 134 days).

Analysis of SuperWASP high-cadence measurements led to identification of 15 peaks above the significance level with $S/N > 4$. The highest peaks with comparable amplitudes were found at $f_1 = 7.90673(6)$ and $f_2 = 7.69662(5)$ c/d (see Fig. 3, bottom panels). We also divided the dataset in three subsets according to the gaps in observations. Subsequently, each of the subsets was analysed individually to confirm frequencies found in the whole dataset. Ten and four significant frequencies were identified in the first and second subset, respectively. In Fourier transform of the third part of the data, which contained data of bad quality with time span of only 16 days, we found only two peaks corresponding to f_1 and f_2. Thus we give only first ten frequencies identified in the complete dataset in Table 1. The uncertainties of the final digits, which are given in parenthesis, were calculated using Monte Carlo simulation, which is implemented in Period04.

Except for independent frequencies, some of the peaks can be considered as a combination of other peaks. Frequency f_5 can be expressed as $f_5 = f_1 + f_2$ within $3 \cdot 10^{-4}$, $f_{10} = f_2 + f_6 - f_3$ within 10^{-3}. However, interpretation of f_{10} as a combination is at least suspicious and one should pay caution in this case. In addition, low-amplitude peaks

$f_2 - f_7$ and $2\,f_2$ were identified below the significance limit. However, according to their low amplitude, these peaks are probably only fortunate coincidences.

An interesting finding is that the peak with the highest amplitude is f_1 in the first subset and in the complete dataset, while in the second part of the data, which has comparable number of points and time span as the first part, the highest peak is at f_2. The same applies for the third subset. Therefore, it is somewhat unclear, which frequency should be considered as the main pulsation frequency. The range of light changes can be estimated from SuperWASP data (clear filter) as 10.88 - 11.02 mag. Theoretical light changes based on semi-amplitudes in table 1 (when all amplitudes are summed) is from 10.86 to 11.05 mag.

Table 1: Frequencies identified in the complete SuperWASP dataset. The errors in the final digits are given in parenthesis.

ID	Frequency [c/d]	Amplitude [mmag]	ID	Frequency [c/d]	Amplitude [mmag]
f_1	7.90673(6)	28.0(4)	f_6	14.7683(5)	3.7(4)
f_2	7.69662(5)	27.1(4)	f_7	7.6119(5)	3.6(4)
f_3	8.1281(2)	11.4(4)	f_8	8.0587(6)	3.3(4)
f_4	6.0163(4)	5.7(4)	f_9	10.9178(7)	2.9(4)
$f_5 = f_1 + f_2$	15.6034(4)	3.8(4)	$f_{10} = f_2 + f_6 - f_3$	14.3361(7)	2.5(4)

According to our frequency analysis we conclude that a new δ Sct-type star CzeV616 Cyg shows multiperiodic behaviour, and deserves further photometric and spectroscopic observations to identify its pulsation modes and to determine its physical characteristics. However, this is out of scope of this discovery note.

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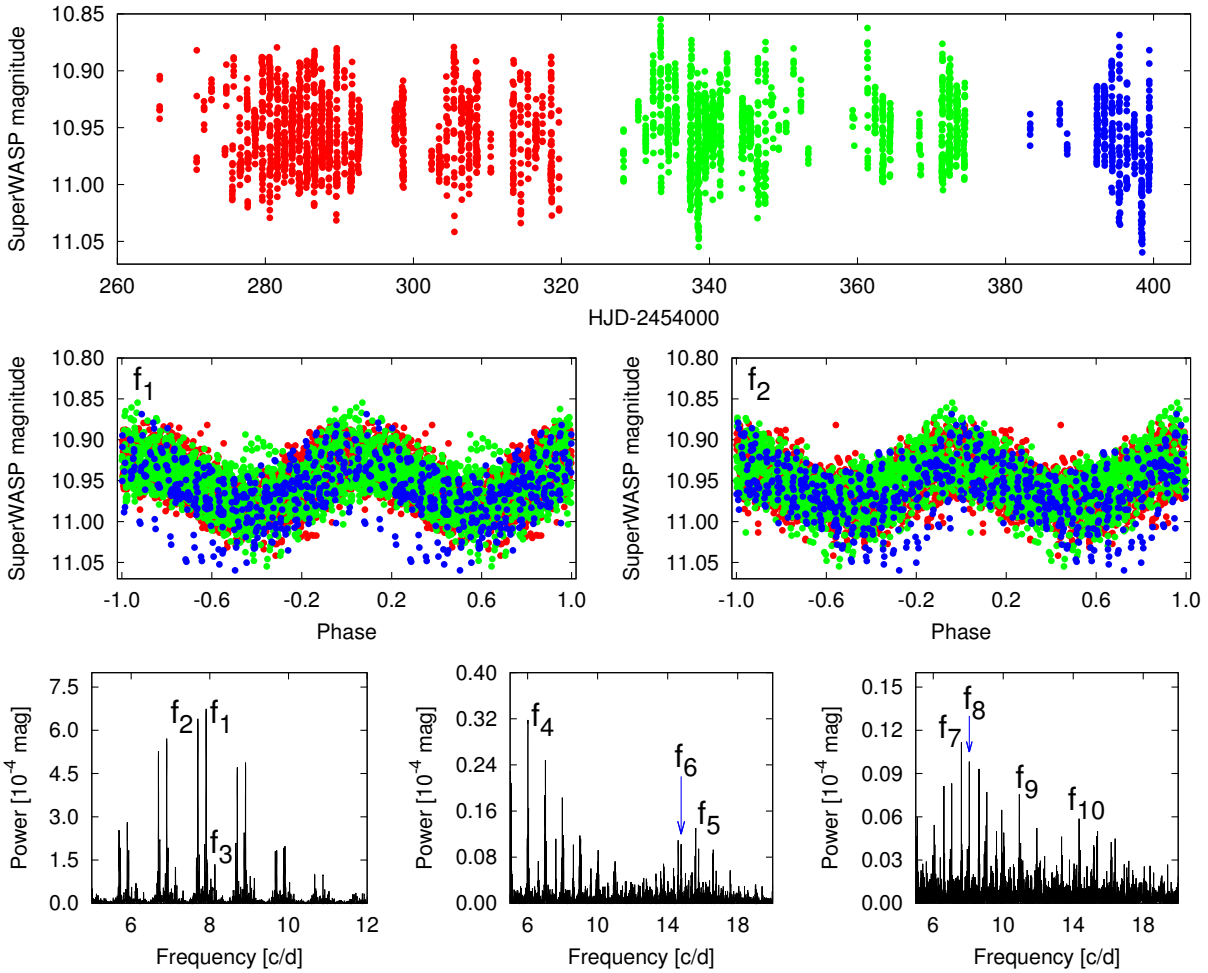

Figure 3: Raw SuperWASP data (top panel) phased with f_1 (middle left panel) and f_2 (middle right panel). Different colour in the top panels corresponds to different subsets, which were analysed. The bottom panels show the power amplitude spectra with identification of the peaks. It is seen that they are dominated with daily aliases. The middle bottom panel illustrates the situation after prewhitening the spectrum with f_1, f_2, and f_3, the bottom right panel shows peaks identified after prewhitening with all previously found peaks.