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CzeV283 AND CzeV397 – NEW RR LYRAE STARS SHOWING BLAZHKO EFFECT

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We present discovery of the Blazhko effect in two fundamental mode RR Lyrae variables CzeV283=USNO-A2.0 0975-17144916 (J2000 $\alpha = 19^{\rm h}55^{\rm m}38\overset{\rm s}{.}1$, $\delta = +13^\circ43'22.4''$, Aql) and CzeV397=USNO-A2.0 0975-11853460 (J2000 $\alpha = 18^{\rm h}29^{\rm m}43\overset{\rm s}{.}3$, $\delta = +12^\circ06'39\overset{''}{.}2$", Her), whose variabilities were unveiled recently (in 2011 and 2012) in the framework of private project dealing with searching for new variables in randomly chosen fields around known variables. This observation program resulted in discovery of more than a hundred new variable stars (see http://www.bsobservatory.org/results.html) among which some interesting cases occurred – e.g. a quadruple eclipsing binary system CzeV343 in Auriga constellation (Cagaš & Pejcha 2012).

The Blazhko effect, known for about century (firstly noted by S. N. Blazhko 1907), manifests itself as amplitude and phase modulations of the light curve. This phenomenon represents actual astrophysical challenge, because its nature remains unexplained. The most recent explanation, which is based on the data from *Kepler* space telescope, deals with the resonance 9:2 between the fundamental mode and the 9th radial overtone (Szabó et al. 2010). A brief overview of the Blazhko effect and proposed models can be found e.g. in Kolenberg (2011).

CzeV283 and CzeV397 join a group of about 270 known Blazhko stars from the Galactic field.[1] Except for results based on space missions, the most significant progresses in Blazhko variables research are *The Konkoly Blazhko survey* (Jurcsik et al. 2009) and works based on *GEOS* database (Le Borgne et al. 2007).

The surroundings of V729 Aql and V1134 Her were observed during three seasons between 2011 and 2013 (see Table 1 with a journal of observation) with a 10 inch f/5.4 Newtonian telescope equipped with a G4-16000 CCD camera[2] (field of view $71' \times 71'$) at the private observatory in Zlín, Czech Republic. As the aim of these measurements was searching for new variables, observations were carried out without filtering to gain the highest possible throughput.

Raw images, with exposure times of 240 and 180 seconds, were calibrated with appropriate dark frames and flat fields. Differential aperture photometry as well as the calibrations were performed using C-MUNIPACK[3] software. USNO-A2.0 0975-17184388

[1]A list with Blazko variables is available at `http://physics.muni.cz/~blasgalf/` (Skarka 2013)
[2]Parameters of the detector can be found at `http://www.gxccd.com/`
[3]`http://c-munipack.sourceforge.net/`

(in CzeV283) and USNO-A2.0 0975-11774493 (in CzeV397) were chosen as comparison stars. In total we gained 910 measurements for CzeV283 in 19 nights with a time span of 413 d and 1255 points for CzeV397 in 22 nights (time span of 678 d). The relative precision of our photometry was about 0.05 mag.

We performed a frequency analysis of our time series with Period04 (Lenz & Breger 2005) to get the basic pulsation periods. As we caught several maxima of both stars (Table 2), we were also able to determine their timings using polynomial fitting. On the basis of our investigations we give

$$\mathrm{HJD}\ \mathrm{T}_{\mathrm{max}} = 2456222.3286(6) + 0.558488(2)\mathrm{E}_{\mathrm{puls}}, \quad (1)$$

for CzeV283 and

$$\mathrm{HJD}\ \mathrm{T}_{\mathrm{max}} = 2456132.3955(4) + 0.58664(3)\mathrm{E}_{\mathrm{puls}}, \quad (2)$$

for CzeV397, respectively. Data of studied stars phased with respect to these elements are plotted in Fig. 1.

Table 1. Journal of observations. The meaning of t is the duration of observation, N is the number of points and TS corresponds to the time span.

CzeV283			CzeV397		
Night [HJD-2450000]	t [hours]	N	Night [HJD-2450000]	t [hours]	N
5834	3.7	39	5830	1.6	27
5836	3.1	38	5835	3.1	43
5851	4.1	34	6095	3.0	26
5856	4.1	36	6101	1.1	19
5857	3.4	39	6102	2.7	47
5867	1.7	17	6121	3.6	64
5868	4.0	45	6131	4.3	69
5869	3.9	44	6132	3.8	66
5875	4.2	44	6145	1.5	22
5876	3.2	35	6152	3.6	64
6204	5.0	88	6153	2.4	41
6210	2.5	42	6155	4.2	68
6212	4.9	87	6157	3.1	56
6220	3.8	64	6158	4.5	75
6221	3.0	52	6159	4.3	75
6222	3.2	56	6180	4.7	79
6223	3.7	65	6181	2.8	40
6246	2.4	43	6483	4.2	66
6247	2.4	42	6494	5.1	89
			6495	4.8	85
			6507	4.1	72
			6508	4.0	62
		Total			
TS=413 d	66.3	910	TS=665 d	68.4	1121

After a few nights it was obvious that the light curves of both stars underwent changes (see Fig. 2), which is the sign of the Blazhko effect. Unfortunately our data were too sparse to estimating the Blazhko period. In the case of CzeV397 we identified a suspicious side peak near f_0, which corresponds to 38 day modulation period. This period gives nice phased light curve, but it needs to be confirmed by further observations.

Table 2. Times of maximum light.

CzeV283	CzeV397
2455836.4148(8)	2456102.4842(4)
2455868.2524(9)	2456132.3955(4)
2456212.2797(5)	2456159.3754(3)
2456222.3286(6)	2456495.5320(14)
	2456508.4267(4)

To have at least a rough idea about the amplitude of the light changes of the stars we used PERIOD04 and fitted data with the sum of sines (the mean light curves in Fig. 1) in the form

$$A(t) = A_0 + \sum_{i=1}^{n} A_i \sin\left[2\pi\left(i\tau + \phi_i\right)\right], \qquad (3)$$

where τ corresponds to the phase of the light curve (fractional part of $\left(\frac{t-T_0}{P}\right)$, where T_0 is the epoch and P is the basic pulsation period). The degree of the fit (n) was chosen according to visual inspection.

For CzeV283 we obtained min-to-max[4] range Δmag = 0.93 and Δmag = 0.67 for CzeV397, respectively.

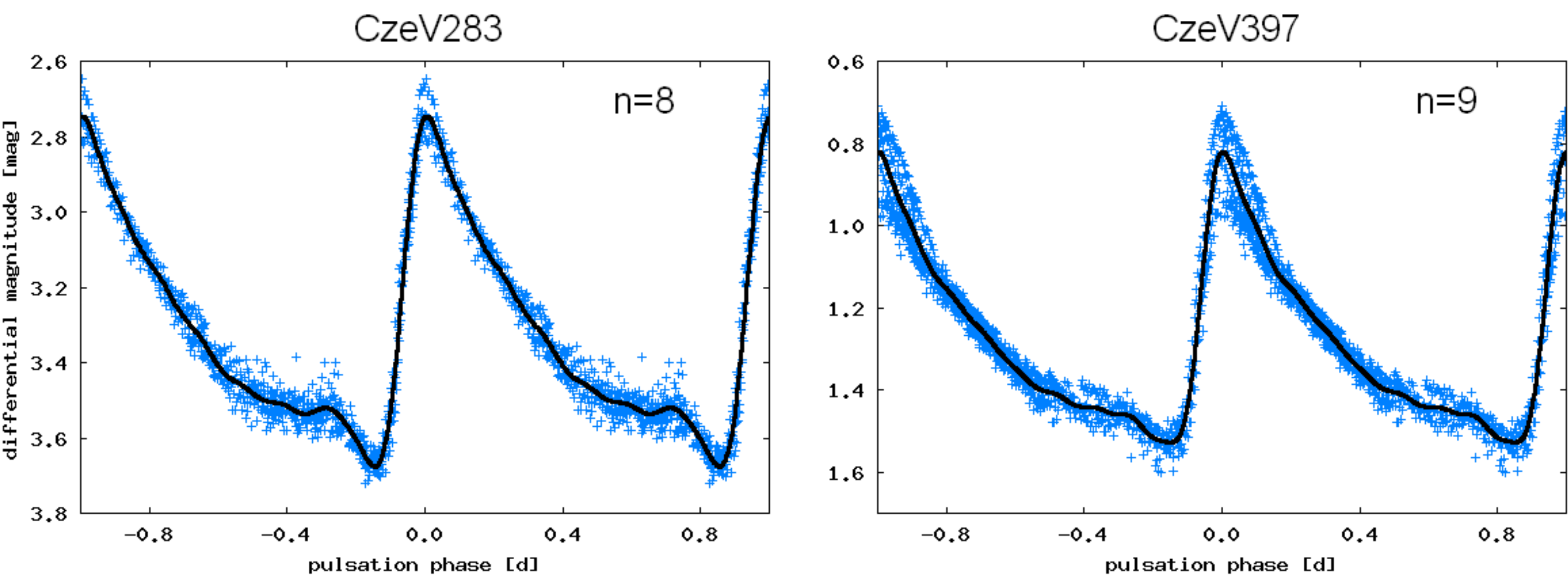

Figure 1. Data of CzeV283 and CzeV397 phased according to eq. 1 and 2, respectively. Solid line represents the fit with the sum of sines with respect to (3) of the degree n.

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[4]We simply substracted minimum value of the fit from maximum.

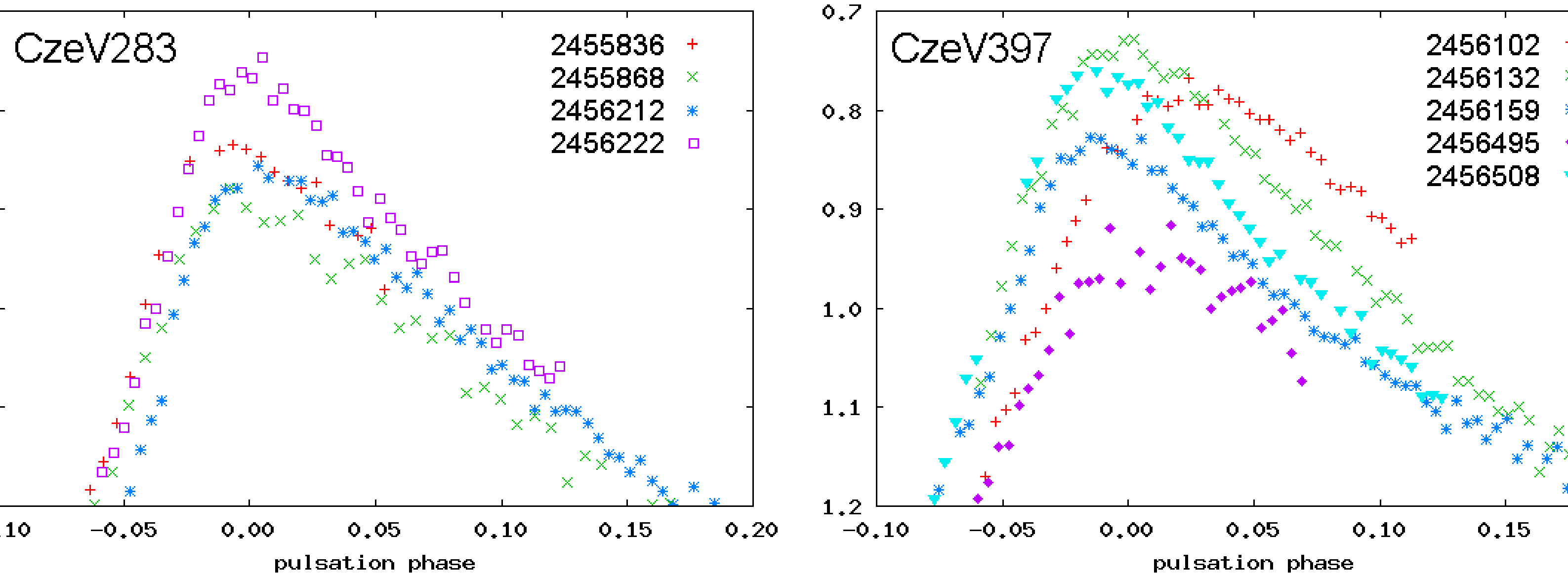

Figure 2. Close-up of the vicinities of the maxima of phased light curves. Change of the shape and amplitude in different nights is easily noticeable.

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