OPEN EUROPEAN JOURNAL ON VARIABLE STARS
November 2016 http://var.astro.cz/oejv ISSN 1801-5964

THREE NEW VARIABLE STARS IN THE FIELD OF KN VUL

Martin Lehký

Úpice Observatory, U Lipek 160, 542 32 Úpice, Czech Republic <makalaki@astro.sci.muni.cz>

Abstract: Three new variable stars were found in the field of EW eclipsing binary KN Vul using 0.40-m f/5 JST reflector of the Astronomical Society in Hradec Králové, Czech Republic. In order to confirm the light variations and to determine precise periods, amplitudes, colour indices and types of variability, vicinity of the new variable stars during the period between October 2010 – October 2011 (13 nights) was observed. The shape of the light curve and basic parameters allowed classification of HKV9 Vul = CzeV254 = USNO-B1.0 1177-0589158 as an EW eclipsing binary (Min I = HJD 2455482.27667 + 0.3328594 × E), HKV12 Vul = CzeV338 = USNO-B1.0 1177-0589357 as a pulsating variable star, BCEP or DSCT (Max = HJD 2455792.48972 + 0.280559 × E), HKV13 Vul = CzeV339 = USNO-B1.0 1176-0576059 as an EW eclipsing binary (Min I = HJD 2455819.32899 + 0.779826 × E).

1 Introduction

The new eclipsing binary star HKV9 Vul, the new pulsating variable star HKV12 Vul and the new eclipsing binary star HKV13 Vul have been discovered in the vicinity of KN Vul during the multi-color photometry of this target using 0.40-m f/5 Jan Šindel Telescope (JST) reflector and G2-1600 CCD camera with a set of *BVRcIc* bandpass filters operated at observing house of the Astronomical Society in Hradec Králové located near Hradec Králové Observatory and Planetarium, Czech Republic. This work presents observations of the new variable stars collected during the period between October 2010 – October 2011 (13 nights). In order to confirm the light variations and to determine precise periods, amplitudes, colour indices and types of variability allowed me to work out the basic parameters of variables and to register them in the Czech Variable Star catalog (CzeV) and the Variable Star Index (VSX).

2 Intrumentation and methodology

All multi-color observations of new variable stars were obtained using the JST Newtonian reflector 400/1967 on German equatorial mount. The camera sensor Kodak KAF 1603 ME has a 1536 x 1024 px size, the effective field of view is about 24' x 16' and thus the angular size of each pixel is 0".8 x 0".8.

The CCD frames were acquired in sequences changing the filters in the following order *VRcIcVRcIc* etc. Typical exposure times were 90-120 s for *V*, 60-90 s for *R*c and 60-90 s for *I*c, depending on weather conditions. The time used is UTC. All the images were calibrated with dark and flat-field frames. Differential instrumental aperture photometry was performed with *C-Munipack* (Motl, 2011). Minima timings of eclipsing binary stars were determined using the Kwee and van Woerden method implemented in *AVE* (Barbera, 2000) and maxima timings of pulsating variable star were determined using *Peranso* (Paunzen&Vanmunster, 2016), polynomial fitting algorithm tool. Possible periods were searched using *PerSea 2.01* (Maciejewski, 2004).

3 Comparison stars

The nearby stars USNO-B1.0 1177-0589416 (cmp), USNO-B1.0 1177-0589942 (ch1) and USNO-B1.0 1176-0574607 (ch2), exposed at the same time as the variables, were chosen as comparison and check stars, respectively. For transformation magnitudes to standard system I used relations between *J* and *K* magnitudes from 2MASS catalog (Cutri et al., 2003) and *BVRcIc* standard magnitudes (Warner, 2007):

$$B = J + 0.198 + 5.2150 * (J-K) - 2.7785 * (J-K)^2 + 1.7495 * (J-K)^3 \quad (1)$$

$$V = J + 0.1496 + 3.5143 * (J-K) - 2.325 * (J-K)^2 + 1.4688 * (J-K)^3 \quad (2)$$

$$Rc = J + 0.1045 + 2.5105 * (J-K) - 1.7849 * (J-K)^2 + 1.123 * (J-K)^3 \quad (3)$$

$$Ic = J + 0.0724 + 1.2816 * (J-K) - 0.4866 * (J-K)^2 + 0.2963 * (J-K)^3 \quad (4)$$

The standard deviations of the magnitudes from the equations above are as large as 0.08 mag for *B*, 0.05 mag for *V*, 0.04 mag for *R*c and 0.035 mag for *I*c, assuming that -0.1 < (*J*-*K*) < 1.0, main sequence star and single star. Resulting *BVRcIc* magnitudes for reference stars and their identification and coordinates are listed in Table 1. The finding chart of the reference stars and variable stars is shown in Figure 1.

Colour indices *J*-*K* of the reference stars are 0.710, 0.292 and 0.417 mag for cmp, ch1 and ch2, respectively. Colour indices *J*-*K* of the variable stars are 0.415, 0.651, 0.699 and 0.744 mag for KN Vul, HKV9, HKV12 and HKV13, respectively.

The light curves of the comparison and check stars did not exhibit any systematic changes and can be considered constant. The standard deviations are *V* = 0.015, *R*c = 0.015, *I*c = 0.017 mag in the case of cmp-ch1 and *V* = 0.020, *R*c = 0.022, *I*c = 0.027 mag in the case of cmp-ch2, respectively.

Table 1: The comparison and check stars used for photometry. *JK* magnitudes were taken from the 2MASS catalog. *BVRcIc* magnitudes were derived with help of (1) to (4) relations (Warner, 2007):

ID	USNO-B1.0	UCAC4	RA (J2000.0)	DE (J2000.0)	*J*	*K*	*B*	*V*	*R*c	*I*c
cmp	1177-0589416	589-101503	19 55 18.472	+27 45 40.39	10.534	9.824	13.660	12.532	11.923	11.377
ch1	1177-0589942	589-101599	19 55 42.038	+27 42 56.66	11.346	11.054	12.873	12.360	12.059	11.759
ch2	1176-0574607	589-101452	19 55 08.999	+27 39 52.61	11.754	11.337	13.770	13.071	12.676	12.298

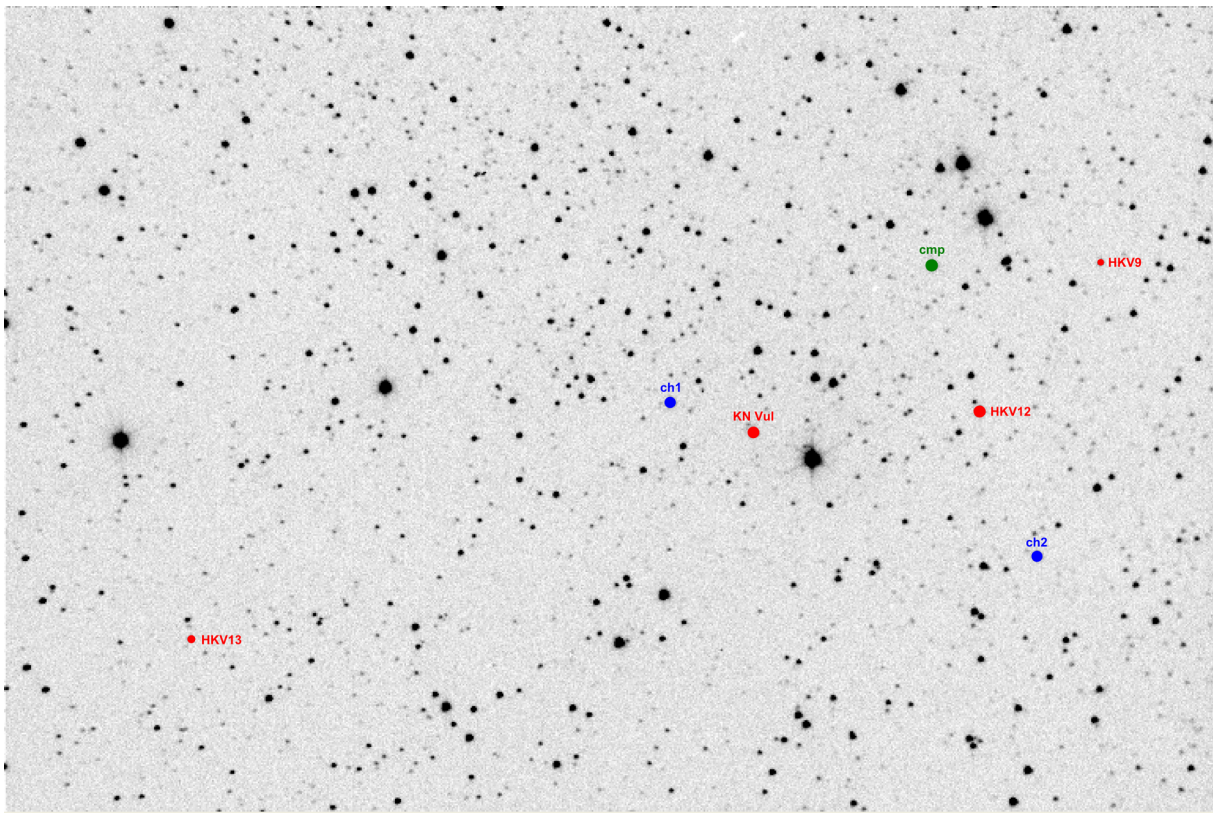

Figure 1. The field of view with variable stars HKV9, HKV12 and HKV13 and comparison stars (the field of view is 24' x 16', N is to the top, E to the left).

4 Results and discussion on the individual objects

New variable stars were found in the vicinity of KN Vul on 12th October 2010 (HKV9) and 18th August 2011 (HKV12, HKV13). Further observations allowed determination of preliminary light elements and classification of variability. Discoveries of HKV9, HKV12 and HKV13 Vul were included to the *Czech Variable Star catalog* on 24th May 2011 (CzeV 254), on 08th January 2012 (CzeV 338 and CzeV 339) and in the *International Variable Star Index* on 25th May 2011 (VSX J195503.2+274543), on 10th January 2012 (VSX J195514.1+274245) and on 08th January 2012 (VSX J195625.2+273813).

Cross identifications HKV9 Vul, HKV12 Vul and HKV13 Vul and coordinates are given in Table 2. Summary of the main data and parameteres of new variable stars are given in Table 6.

Table 2: Cross-identifications and coordinates of new variable stars HKV9, HKV12 and HKV13 Vul.

ID	CzeV	VSX	USNO-B1.0	UCAC4	RA (J2000.0)	DE (J2000.0)
HKV9	254	J195503.2+274543	1177-0589158	589-101431	19 55 03.231	+27 45 43.60
HKV12	338	J195514.1+274245	1177-0589357	589-101479	19 55 14.169	+27 42 45.69
HKV13	339	J195625.2+273813	1176-0576059	589-101787	19 56 25.189	+27 38 13.52

HKV9 Vul was observed during 13 nights (2010 October – 2011 October; time span 369 days, 63.2 hours of observation; 2408 data points), HKV12 Vul and HKV13 Vul were observed during 9 nights (2011 August – 2011 October; time span 59 days, 47.3 hours of observation; 1679 and 1487 data points, respectively).

4.1 HKV9 Vul = CzeV254 = USNO-B1.0 1177-0589158

The data from the first night, JD 2455482, showed a minimum and maximum that seemed to be part of a typical EW light curve. Further observations confirmed this initial suggestion. During 13 nights 12 primary minima (34 measurements in *VRcIc* filters) and 7 secondary minima (21 measurements in *VRcIc* filters) were obtained. Values of minima timings are reported in Table 3. An approximate period valid for the whole time span of my data was refined by linear least-squares analysis of 55 minima timings. The basic minimum was improved as well in the process. All published times are heliocentric JD. Final ephemeris and its uncertainty is:

Min. I = HJD *2455482.2767 (± 0.0005) + 0.3328594 (± 0.0000005)* d × *E.* *(5)*

Figure 2 shows the phase curve of HKV9 Vul inferred from all 2408 data points (716 in *V* band, 864 in *R*c band and 828 in *I*c band). Changes of brightness observed during sessions were $V = 15.13 – 15.88$ (i.e. amplitude of 0.75 mag), $R\text{c} = 14.58 – 15.28$ (i.e. amplitude of 0.70 mag) and $I\text{c} = 13.97 – 14.67$ (i.e. amplitude of 0.70 mag). The brightness at the secondary minimum is $V = 15.86$, $R\text{c} = 15.26$ and $I\text{c} = 14.65$ mag. The duration of the eclipse is not easy to estimate because of gradual change of the light curve. However, if we consider the moment of the start/end of the eclipse as the moment when the descending/ascending branch breaks from the strictly straight line, it is roughly 0.15 d. The shape of the EW light curve is a very slightly asymmetric, which may indicate a presence of O'Connell effect (O'Connell, 1951). The first maximum is brighter than the second one and the magnitude differences in maxima are $(\text{Max II} – \text{Max I})_V = 0.07 \pm 0.04$ mag, $(\text{Max II} – \text{Max I})_{Rc} = 0.02 \pm 0.02$ mag and $(\text{Max II} – \text{Max I})_{Ic} = 0.03 \pm 0.02$ mag. Differences of maxima brightness were determined using polynomial fitting algorithm toll implemented in *Peranso* (Paunzen & Vanmunster, 2016).

The Table 3 contains eight columns: 1) heliocentric julian date of minimum based on coordinated universal time UTC, 2) error of minimum determination in days, 3) identification of minima type, primary I or secondary II, 4) epoch, 5) *O–C* value in days with respect to refined period and basic minimum, 6) photometric band, 7) total number of measurements / number of the data on descentding branch of the light curve and 8) remarks.

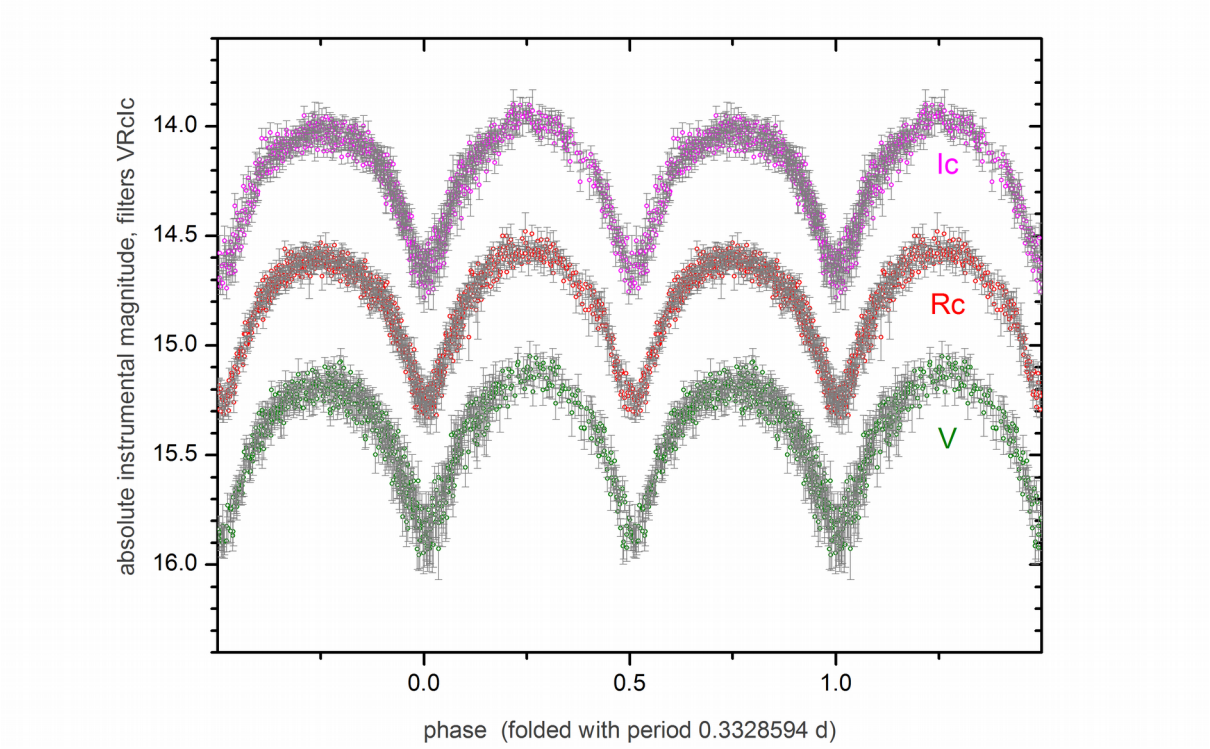

Figure 2. The phased light curve of the binary system HKV9 Vul in *V*, *R*c and *I*c filters.

Table 3: The minima timings of binary system HKV9 Vul.

Hel. J.D.	Error	Type	Epoch	*O* – *C*	Filter	N	Remarks
2455482.27768	0.00075	I	0	0.00101	*V*	59/18	DISCOVERY
2455482.27661	0.00067	I	0	– 0.00006	*R*c	65/20	basic minimum
2455482.27714	0.00067	I	0	– 0.00047	*I*c	63/18	
2455499.24996	0.00077	I	51	– 0.00254	*V*	59/12	
2455499.25019	0.00070	I	51	– 0.00231	*R*c	66/15	
2455499.24991	0.00082	I	51	– 0.00259	*I*c	62/15	
2455500.25276	0.00097	I	54	0.00168	*V*	64/22	
2455500.25298	0.00100	I	54	0.00190	*R*c	78/22	
2455500.25312	0.00074	I	54	0.00204	*I*c	70/21	
2455705.45914	0.00062	II	670.5	0.00026	*V*	49/15	
2455705.45991	0.00068	II	670.5	0.00103	*R*c	59/16	
2455705.46002	0.00044	II	670.5	0.00114	*I*c	53/17	
2455792.33540	0.00077	II	931.5	0.00023	*V*	84	
2455792.33558	0.00045	II	931.5	0.00040	*R*c	89	
2455792.33529	0.00070	II	931.5	0.00012	*I*c	89	
2455792.50215	0.00090	I	932	0.00055	*V*	84	
2455792.50153	0.00049	I	932	– 0.00007	*R*c	89	
2455792.50149	0.00068	I	932	– 0.00011	*I*c	89	
2455796.49235	0.00159	I	944	– 0.00357	*V*	60/38	
2455796.49464	0.00090	I	944	– 0.00128	*R*c	79/48	
2455796.49299	0.00088	I	944	– 0.00293	*I*c	81/48	
2455797.49179	0.00115	I	947	– 0.00271	*V*	53/41	
2455797.49454	0.00096	I	947	0.00005	*R*c	67/48	
2455797.49351	0.00039	I	947	– 0.00099	*I*c	61/46	
2455802.32297	0.00095	II	961.5	0.00201	*V*	49	
2455802.32251	0.00036	II	961.5	0.00155	*R*c	53	

2455802.32321	0.00070	II	961.5	0.00225	*I*c	52	
2455802.48735	0.00104	I	962	– 0.00004	*V*	49	
2455802.48771	0.00107	I	962	0.00032	*R*c	53	
2455802.48599	0.00060	I	962	– 0.00140	*I*c	52	
2455815.46819	0.0017	I	1001	– 0.0007	*R*c	42/36	uncertain
2455817.29981	0.00187	II	1006.5	0.00018	*V*	47	
2455817.30063	0.00070	II	1006.5	0.00100	*R*c	61	
2455817.29907	0.00058	II	1006.5	– 0.00056	*I*c	60	
2455817.46656	0.00090	I	1007	0.00050	*V*	47	
2455817.46728	0.00077	I	1007	0.00122	*R*c	61	
2455817.46575	0.00039	I	1007	– 0.00031	*I*c	60	
2455819.29735	0.00133	II	1012.5	0.00057	*V*	53	
2455819.29701	0.00096	II	1012.5	0.00023	*R*c	57	
2455819.29738	0.00036	II	1012.5	0.00060	*I*c	57	
2455819.46484	0.00109	I	1013	0.00163	*V*	53	
2455819.46403	0.00048	I	1013	0.00082	*R*c	57	
2455819.46229	0.00098	I	1013	– 0.00092	*I*c	57	
2455829.28225	0.00100	II	1042.5	– 0.00032	*V*	75	
2455829.28252	0.00069	II	1042.5	– 0.00045	*R*c	92	
2455829.28239	0.00200	II	1042.5	– 0.00018	*I*c	88	
2455829.44825	0.00151	I	1043	– 0.00074	*V*	75	
2455829.44831	0.00071	I	1043	– 0.00068	*R*c	92	
2455829.44889	0.00140	I	1043	– 0.00010	*I*c	88	
2455851.25036	0.00086	II	1108.5	– 0.00092	*V*	59	
2455851.25113	0.00049	II	1108.5	– 0.00015	*R*c	61	
2455851.25162	0.00046	II	1108.5	0.00034	*I*c	59	
2455851.41955	0.00150	I	1109	0.00184	*V*	59	
2455851.41699	0.00111	I	1109	– 0.00072	*R*c	61	
2455851.41872	0.00094	I	1109	0.00101	*I*c	59	

4.2 HKV12 Vul = CzeV338 = USNO-B1.0 1177-0589357

The variability of the USNO-B1.0 1177-0589357 star was detected on 18th August 2011. The light curve obtained during 5.9 hours session showed an obvious minimum and maximum. The asymmetric shape, a short period and a very small amplitude in *R*c and *I*c filters indicated that the new variable is a pulsating star. Values of 7 maxima timings (19 measurements in *VR*c*I*c filters) are listed in Table 4. An approximate period was again refined using linear least-squares analysis of all 19 maxima timings. The basic maximum was improved upon as well in the process. All published times are heliocentric JD. The resulting ephemeris is:

Max = HJD *2455792.4897 (± 0.0013) + 0.280559 (± 0.000008)* d × *E.* *(6)*

Figure 4 shows the phase curve of HKV12 Vul inferred from all 1679 data points (533 in *V* band, 578 in *R*c band and 568 in *I*c band). Changes of brightness observed during sessions were *V* = 12.79 – 12.89 (i.e. amplitude of 0.10 mag), *R*c = 12.30 – 12.38 (i.e. amplitude of 0.08 mag) and *I*c = 11.78 – 11.84 (i.e. amplitude of 0.06 mag). A very small amplitude in the *I*c band and almost twice larger amplitude in the *V* band, together with the asymmetric light curve, with a rise time of 0.163 ± 0.002 d (i.e. about 58% of the period), indicates that HKV12 Vul is a pulsating star.

From the filtered sessions the mean *V* magnitude of 12.84 ± 0.03 and the mean *R*c magnitude of 12.34 ± 0.03, with the colour index (*V*–*R*c) of 0.50 ± 0.05 mag, were measured. Unfortunately, a rough estimate of the spectral type of this pulsating star from multi-color photometry is impossible because there is a very high interstellar reddening *E(B–V)* = 3.1 mag (The NASA / IPAC Infrared Science Archive or IRSA, Schlegel, Finkbeiner & Davis, 1998). This value represent integrated value along the line of sight.

The Fourier frequency spectrum in the range up to 5 d shows a dominant period 0.2804 d (3.566300 c/d) with a power value of 0.262. After prewhitening, no other periodic oscillations with a power value over 0.02 were found. Considering the pulsation period and the amplitude of variations, the star can be classified either as a BCEP or DSCT star. For more detailed study and classification, the spectroscopic observations would be required.

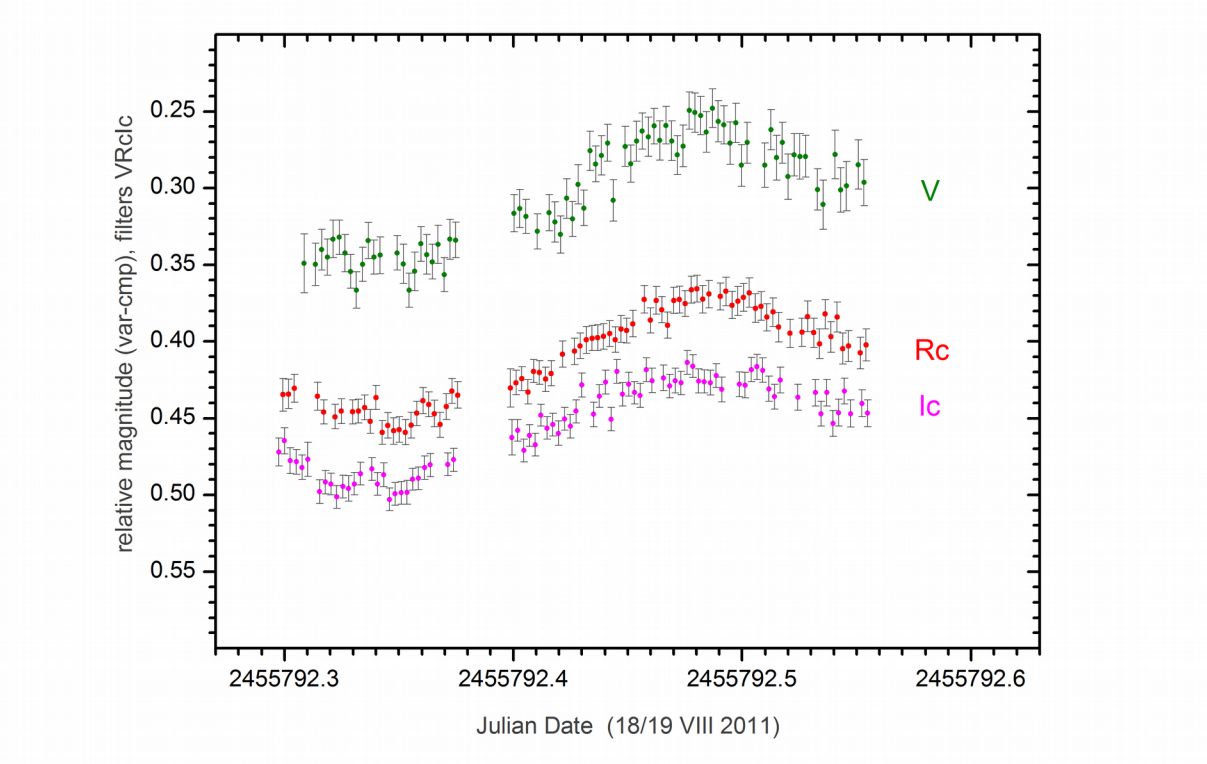

Figure 3. CCD *V*, *R*c and *I*c light curves of pulsating star HKV12 Vul obtained during HJD 2455792 night. There is a clearly visible maximum, chosen as the basic one for the processing of the data.

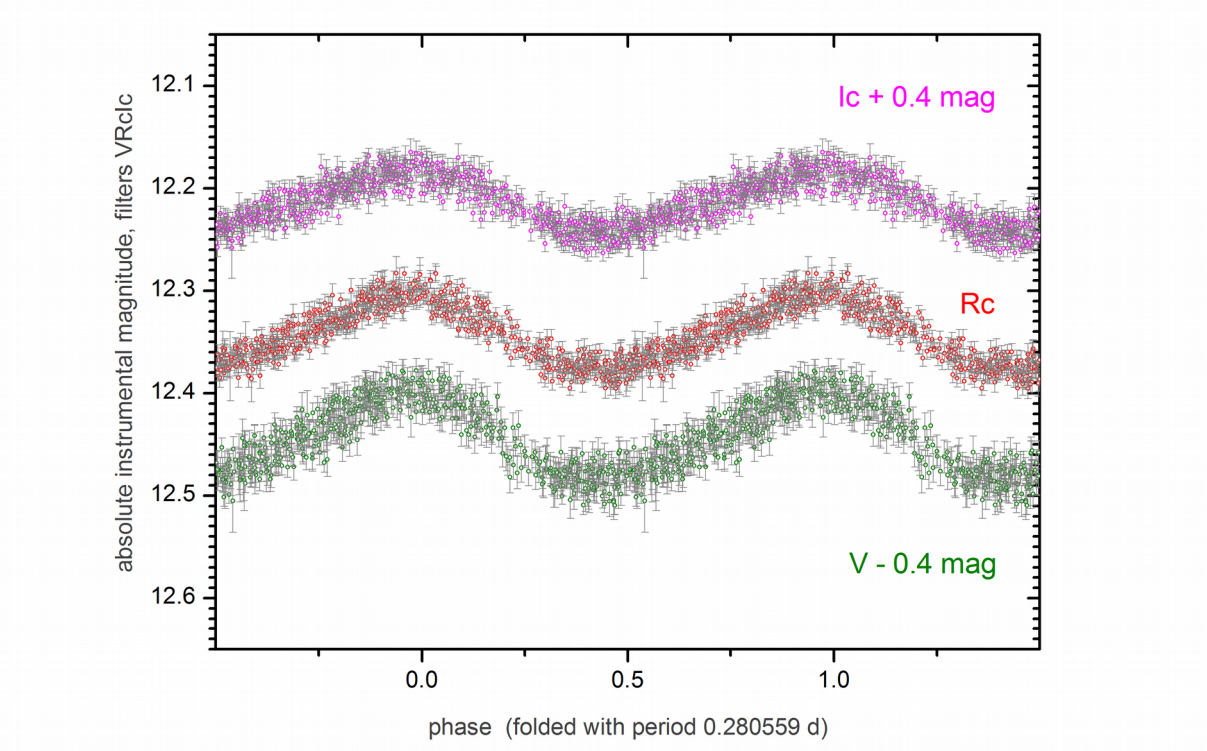

Figure 4. The phased light curve of the pulsating star HKV12 Vul in *V*, *R*c and *I*c filters.

The Table 4 contains seven columns: 1) heliocentric julian date of maximum based on coordinated universal time UTC, 2) error of maximum determination in days, 3) epoch, 4) *O–C* value in days after refined period and basic maximum, 5) photometric band, 6) total number of measurements and 7) remarks.

Table 4: The maxima timings of HKV12 Vul.

Hel. J.D.	Error	Epoch	*O – C*	Filter	N	Remarks
2455705.51991	0.00150	– 310	0.00345	*V*	49	
2455705.51689	0.00083	– 310	0.00043	*R*c	59	
2455705.51620	0.00230	– 310	– 0.00026	*I*c	51	
2455792.48642	0.00063	0	– 0.00330	*V*	78	DISCOVERY
2455792.48594	0.00075	0	– 0.00378	*R*c	86	basic maximum
2455792.48669	0.00110	0	– 0.00303	*I*c	81	
2455796.41311	0.00078	14	– 0.00444	*V*	75	
2455796.41056	0.00085	14	– 0.00698	*R*c	82	
2455796.41193	0.00125	14	– 0.00562	*I*c	84	
2455797.53304	0.00087	18	– 0.00674	*R*c	62	
2455817.46629	0.00106	89	0.00683	*V*	56	
2455817.46652	0.00108	89	0.00706	*R*c	54	
2455817.46673	0.00128	89	0.00727	*I*c	59	
2455819.43084	0.00080	96	0.00746	*V*	56	
2455819.43076	0.00085	96	0.00738	*R*c	56	
2455819.42889	0.00093	96	0.00551	*I*c	56	
2455851.40455	0.00070	210	– 0.00254	*V*	58	
2455851.40453	0.00069	210	– 0.00256	*R*c	59	
2455851.40100	0.00250	210	– 0.00609	*I*c	57	

4.3 HKV13 Vul = CzeV339 = USNO-B1.0 1176-0576059

The light curve from the discovery session, JD 2455792, showed a clear minimum. Follow-up latter observations successively confirmed that HKV13 Vul is an EW eclipsing binary. Altogether 5 primary minima (15 measurements in *VRcIc* filters) and 2 secondary minima (6 measurements in *VRcIc* filters) were obtained. Values of minima timings are reported in Table 5. An approximate period valid for the whole time span of my data was refined using linear least-squares analysis of all 21 minima timings. The basic minimum was improved as well in the process. All published times are heliocentric JD. Final ephemeris and its uncertainty is:

Min. I = HJD *2455819.32899 (± 0.00095) + 0.779826 (± 0.000041)* d × *E.* *(7)*

Figure 5 shows the phase curve of HKV13 Vul inferred from all 1487 data points (469 in *V* band, 513 in *R*c band and 505 in *I*c band). Changes of brightness observed during sessions were *V* = 15.08: – 15.45: (i.e. amplitude of 0.37: mag), *R*c = 14.30 – 14.66 (i.e. amplitude of 0.36 mag) and *I*c = 13.39 – 13.79 (i.e. amplitude of 0.40 mag). The brightness at the secondary minimum is *V* = 15.43:, *R*c = 14.62 and *I*c = 13.73 mag. The duration of the eclipse is not easy to estimate because of gradual change of the light curve. However, if we consider the moment of the start/end of the eclipse as the moment when the descending/ascending branch breaks from the strictly straight line, it is roughly 0.18 d. The shape of the light curve is asymmetric. Negative O'Connell effect is clearly visible. Presence of O'Connell effect in the *V* light curve is uncertain due to large scatter of the observations. The second maximum is brighter than the first one and the magnitude differences in maxima are $(\text{Max II} - \text{Max I})_V \approx 0 \pm 0.06$ mag, $(\text{Max II} - \text{Max I})_{Rc} = -0.03 \pm 0.02$ mag and $(\text{Max II} - \text{Max I})_{Ic} = -0.06 \pm 0.02$ mag. There is an obvious dependence between maxima differences and the colours.

The Table 5 contains eight columns: 1) heliocentric julian date of minimum based on coordinated universal time UTC, 2) error of minimum determination in days, 3) identification of minima type, primary I or secondary II, 4) epoch, 5) *O–C* value in days after refined period and basic minimum, 6) photometric band, 7) total number of measurements / number of the data on decreasing branch of the light curve and 8) remarks.

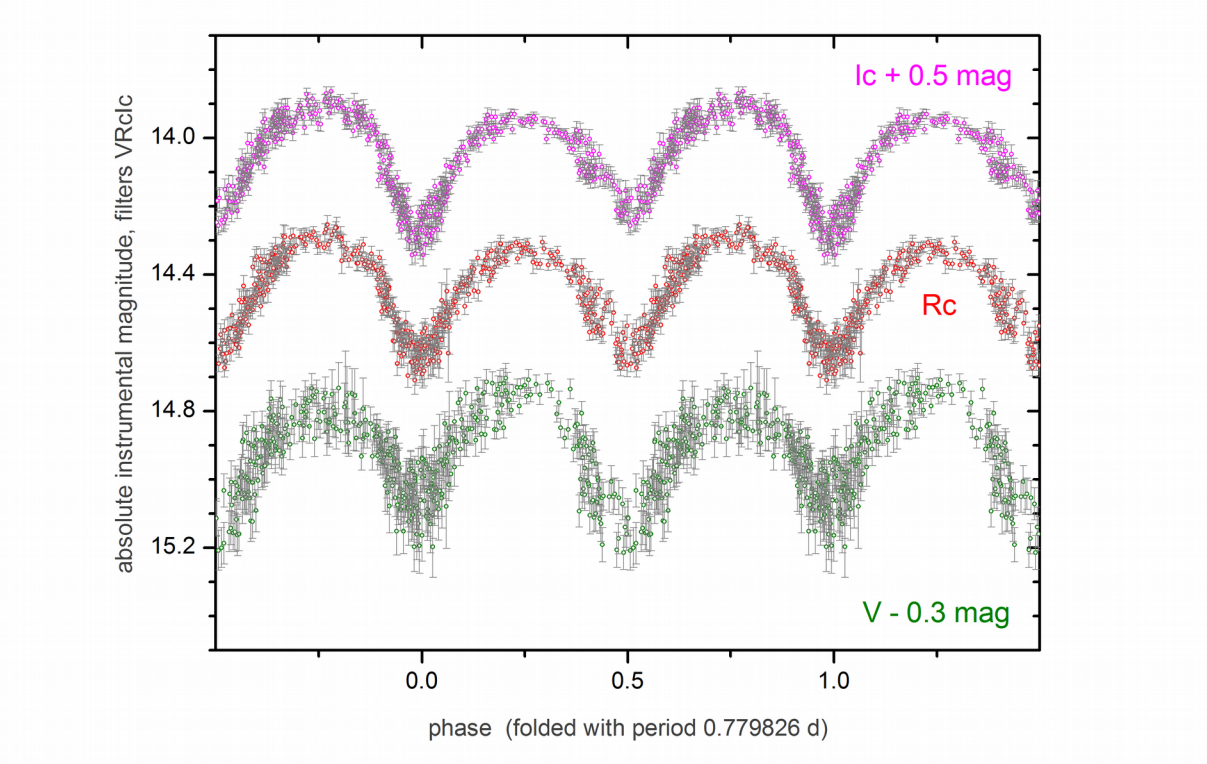

Figure 5. The phased light curve of the binary system HKV13 Vul in *V*, *R*c and *I*c filters.

Table 5: The minima timings of HKV13 Vul.

Hel. J.D.	Error	Type	Epoch	*O* – *C*	Filter	N	Remarks
2455792.42245	0.00595	II	– 34.5	– 0.00254	*V*	66/21	DISCOVERY
2455792.42100	0.00280	II	– 34.5	– 0.00398	*R*c	73/23	
2455792.42222	0.00420	II	– 34.5	– 0.00276	*I*c	69/23	
2455797.48897	0.00550	I	– 28	– 0.00488	*V*	41/25	
2455797.49083	0.00200	I	– 28	– 0.00302	*R*c	42/36	
2455797.49144	0.00098	I	– 28	– 0.00241	*I*c	40/24	
2455815.43515	0.00900	I	– 5	0.00530	*V*	32/21	
2455815.43789	0.00890	I	– 5	0.00804	*R*c	46/30	
2455815.43733	0.00850	I	– 5	0.00748	*I*c	43/28	
2455817.38180	0.00148	II	– 2.5	0.00238	*V*	52/23	
2455817.38416	0.00128	II	– 2.5	0.00474	*R*c	62/29	
2455817.38492	0.00129	II	– 2.5	0.00550	*I*c	55/26	
2455819.32954	0.00250	I	0	0.00058	*V*	52/10	basic minimum
2455819.33137	0.00142	I	0	0.00239	*R*c	48/11	
2455819.33150	0.00120	I	0	0.00252	*I*c	53/14	
2455829.46240	0.00228	I	13	– 0.00433	*V*	74/60	
2455829.46287	0.00074	I	13	– 0.00386	*R*c	87/64	
2455829.46345	0.00099	I	13	– 0.00328	*I*c	81/61	
2455851.29797	0.00134	I	41	– 0.00389	*V*	50/20	
2455851.30120	0.00171	I	41	– 0.00066	*R*c	48/20	
2455851.29851	0.00139	I	41	– 0.00335	*I*c	47/20	

5 Conclusions

I reported the discovery of three new short-period variable stars in the field of KN Vul. Subsequent observations allowed me to derive precise ephemerides. Based on these parameters and shapes of the light curves, I classified the HKV9 and HKV13 as EW eclipsing binaries and HKV12 as a BCEP or DSCT pulsating variable, but the spectroscopic observations are necessary to confirm this classification.

Table 6: Main parameters of new variable stars HKV9, HKV12 and HKV13 Vul.

ID	Epoch (HJD)	Period	*V*	*Rc*	*Ic*	Type
HKV9	2455482.27667 ± 0.00045	0.3328594 ± 0.0000005	15.13–15.88	14.58–15.28	13.97–14.67	EW
HKV12	2455792.48972 ± 0.00129	0.280559 ± 0.000008	12.79–12.89	12.30–12.38	11.78–11.84	BCEP / DSCT
HKV13	2455819.32899 ± 0.00095	0.779826 ± 0.000041	15.08–15.45	14.30–14.66	13.39–13.79	EW

6 Acknowledgments

In this research I used the SIMBAD and VizieR databases operated by the Centre de Données Astronomiques (Strasbourg) and the VSX (Variable Star Index) database. This research has made use of the NASA/ IPAC Infrared Science Archive, which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. I acknowledge an overall support of the Úpice Observatory, the Astronomical Society in Hradec Králové (ASHK) and the Astronomical Institute of the Charles University in Prague. I would like to thank Ondřej Pejcha, Miroslav Brož and Marek Skarka for their help and assistance.

References:

Barbera, R., 2000, AVE http://www.astrogea.org/soft/ave/introave.htm

Cutri, R. M., Skrutskie, M. F., van Dyk, S., 2003, VizieR: 2MASS All-Sky Catalog, 2246 (2003yCat.2246....0C)

Maciejewski, G., 2004, PerSea 2.01

Motl, D., 2011, C-Munipack http://c-munipack.sourceforge.net/

O'Connell D.J.K., 1951, Pub. Riverview College Obs., 2, p.85-100 (1951PRCO....2...85O)

Paunzen, E., Vanmunster, T., 2016, Peranso. AN, 337, p.239 (2016AN....337..239P)

Schlegel D.J., Finkbeiner D.P., Davis M., 1998, Maps of Dust Infrared Emission for Use in Estimation of Reddening and Cosmic Microwave Background Radiation Foregrounds. ApJ, 500, p.525 (1998ApJ...500..525S)

Simbad Astronomical Database, 2012 *http://simbad.u-strasbg.fr/simbad/*

VizieR, 2012 *http://vizier.u-strasbg.fr/viz-bin/VizieR*

Warner B.D., 2007, Initial Results from a Dedicated H-G Project. Minor Planet Bulletin, Vol. 34, No. 4, p. 113-119 (*2007MPBu...34..113W*)

Watson, C.L., 2006, The international Variable Star Index (VSX). Society for Astronomical Sciences 25th Annual Symposium, 25, p.47 (*2006SASS...25...47W)*