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BVR_CI_C PHOTOMETRIC OBSERVATIONS OF V733 Cep (PERSSON'S STAR)

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Photometric variability is a widespread characteristic of the pre-main sequence (PMS) stars. FU Orionis (FUor) outbursts are a very rare phenomenon but with an important role in stellar evolution (Herbig, 1977). An increase in optical brightness of the order of 4-5 magnitudes, an F-G supergiant spectrum with broad blue-shifted Balmer lines, strong infrared excess and connection with reflection nebulae are the main characteristics of FUors (Reipurth, 1990). According to Hartmann and Kenyon (1985) the FUor outburst is a result of a major increase of accretion from a circumstellar disk on the stellar surface. Another class of PMS objects with high amplitude variations has for a prototype the variable star UX Orionis (UXor). UXors are intermediate mass stars displaying sudden drops in brightness of up to 3 mag. probably caused by variable circumstellar extinction (Natta et al., 1997).

The PMS object V733 Cep (Persson's star) is located in the dark cloud L1216 near to Cepheus OB3 association. The variability of V733 Cep is discovered by Swedish amateur astronomer Roger Persson in 2004 (Persson, 2004). He noted the presence of the star on the red POSS-II image (1991) and its absence on the corresponding POSS-I image (1953). The star is visible also on a Palomar Quick-V plate from 1984. A R-band CCD image of V733 Cep was taken with the 88 inch telescope on Mauna Kea, Hawaii, on 2004 October 9. The magnitude, measured from this observation is about $R = 17\overset{\mathrm{m}}{.}3$ (Reipurth et al., 2007). Comparing this value with the data from USNO-B catalog, Reipurth et al. (2007) conclude that the star has faded by $1\overset{\mathrm{m}}{.}6$ (R) over a time period of about 13 yr. The authors suspect a possible outburst in the period 1953-1984 and find great spectral similarities to FU Ori itself.

In this paper we present BVR_cI_c photometric data of V733 Cep obtained in the period February 2007 - February 2008. Our observations were performed at two observatories with three telescopes: the 2-m Ritchey-Chretien-Coude and 50/70/172 cm Schmidt telescopes of the National Astronomical Observatory Rozhen (Bulgaria) and the 1.3-m Ritchey-Chretien telescope of the Skinakas Observatory[1] of the Institute of Astronomy, University of Crete (Greece). Five different CCD cameras were used during the period of our photometric observations. The technical parameters and chip specifications for the CCD cameras used are summarized in Table 1. All frames were taken through a standard Johnson-Cousins set of filters. Aperture photometry was performed using IDL DAOPHOT routines. All frames obtained with the 2-m RCC, the 1.3-m RC the 50/70 cm Schmidt telescope were reduced using the same aperture of about $3''.0$ radius.

[1]Skinakas Observatory is a collaborative project of the University of Crete, the Foundation for Research and Technology - Hellas, and the Max-Planck-Institut für Extraterrestrische Physik.

Table 1. CCD cameras and chip specifications

Telescope	CCD type	Size	Pixel size	Field	RON
2-m RCC	VersArray 1300B	1340×1300	20μm	$5\farcm6 \times 5\farcm6$	2.8ADU/rms
1.3-m RC	Photometrics CH360	1024×1024	24μm	$8\farcm5 \times 8\farcm5$	2.6ADU/rms
1.3-m RC	ANDOR DZ436-BV	2048×2048	13.5μm	$9\farcm6 \times 9\farcm6$	5.3ADU/rms
Schmidt	ST 8	1530×1020	9μm	$28' \times 18\farcm7$	6.2ADU/rms
Schmidt	ST 11000	4008×2672	9μm	$73' \times 49'$	13ADU/rms

In order to facilitate transformation from instrumental measurements to the standard system a sequence of fifteen comparison stars in the field of V733 Cep was calibrated in BVR_cI_c bands. The standard stars used for comparison are of great importance for the correct magnitude estimation. In regions of star formation like the Cepheus L1216 dark cloud a great percentage of stars can be photometric variables. Calibrations were made with the 1.3-m RC telescope during four clear nights in June and July 2007. Standard stars from Landolt (1992) were used as a reference. The finding chart (R band images obtained with the 1.3-m RC telescope) of the comparison sequence is presented in Fig. 1. The field is $8\farcm5 \times 8\farcm5$, centered on V733 Cep. North is at the top and east to the left. Table 2 (available through the IBVS website as `5831-t2.tex`) contains our photometric data for the $BVRI$ comparison sequence. The corresponding mean errors of the mean are listed, too.

Three stars from our list (C, G and N) were also measured by Pozzo et al. (2003) in BVI bands. Comparing our magnitudes with the data reported in Pozzo et al. (2003) we find a good agreement for I and V values. Only for B magnitudes there are differences at about $0\overset{\mathrm{m}}{.}2$. Three of stars primary selected for our comparison sequence appear to be photometric variables unknown to the present. The USNO-B1.0 identification number, the coordinates of the stars and the observed minimal and maximal values for I and V bands are summarized in Table 3. The stars are named Var. 1, Var. 2, and Var. 3 and they are also marked on Fig. 1. One of them Var. 1 show a very high amplitude of brightness variation ($\Delta V = 2\overset{\mathrm{m}}{.}98$) and it is probably a long period variable of Mira type. Var. 2 lie at about $4'$ south-east from V733 Cep in the same dark cloud and it is probably a PMS object.

Table 3. New variable stars in the field of V733 Cep

Star	USNO-B1	RA J2000	DE J2000	$I_{\max}$	$I_{\min}$	$V_{\max}$	$V_{\min}$
Var. 1	1525-0418386	22:53:46.53	62:34:58.6	13.88	16.24	16.28	19.26
Var. 2	1525-0418333	22:53:36.22	62:31:46.8	13.87	14.54	16.36	17.38
Var. 3	1525-0418196	22:53:15.69	62:35:27.9	13.06	13.33	15.26	15.61

The results from our CCD photometric observations are given in Table 4. The table contains Date, the Julian Date, the I_c, R_c, V and B magnitudes. Our photometric observations of V733 Cep in the period February 2007 - February 2008 show that the brightness of the star is almost steady. We observed only a low amplitude fluctuations of about $0\overset{\mathrm{m}}{.}1$ (I) around the middle values. Using our comparison sequence we measured the plate scans from POSS-II and Quick-V. The corresponding photometric values are: $V = 17\overset{\mathrm{m}}{.}75$ (Aug. 27, 1984), $I = 13\overset{\mathrm{m}}{.}77$ (Jul. 24, 1991), $R = 16\overset{\mathrm{m}}{.}00$ (Sep. 3, 1991) and $B = 20\overset{\mathrm{m}}{.}78$ (Aug. 9, 1991). The light curve of V733 Cep from all known observations is plotted on Fig. 4. On the figure the arrow marks the limit of the red plate from POSS-I (Oct. 31, 1953).

Our photometric data suggest that in the period Feb. 2007 - Feb. 2008 the star

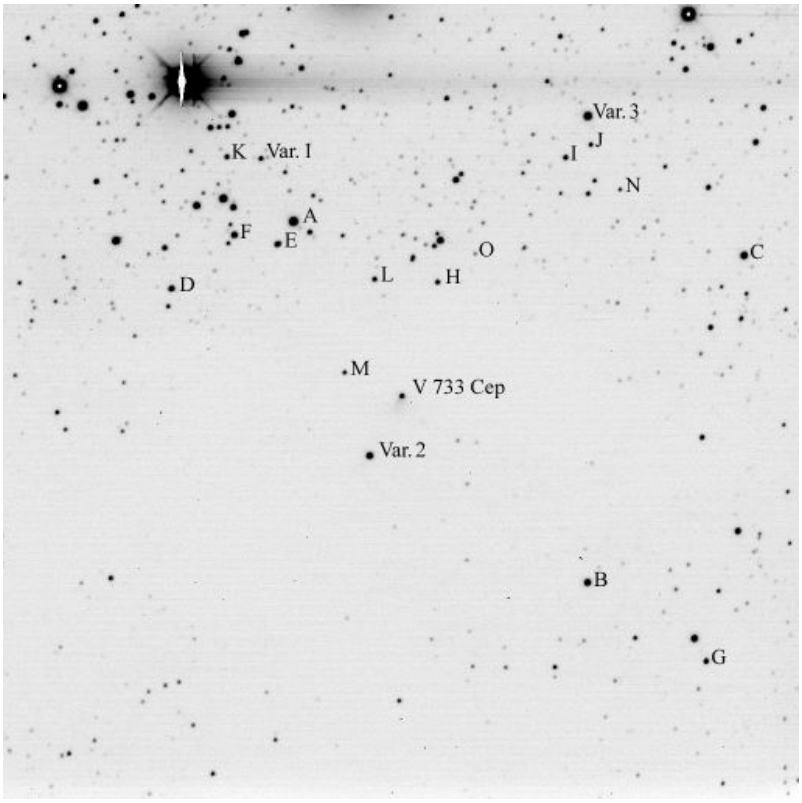

Figure 1. A finding chart of the comparison sequence in the field of V733 Cep

brightness is similar to the measured from POSS-II and Quick-V plates (Fig. 4). Thus the photometric behavior of V733 Cep appears different from the well studied FUors. A main photometric characteristic of FUors is the slow decreases in brightness after the outburst (Clarke et al., 2005). The two observed minimums (on POSS-I and on Oct. 2004) can be explained by a variable extinction from the circumstellar environment - a UXor type of variability. On the other hand the observed amplitude of V733 Cep ($\sim$ 5 mag. in red) is extremely high for this type of variability. Only a few UXors such as V1184 Tau have a similar photometric behavior (Semkov et al., 2008). The construction of the historical light curve of V733 Cep would be very important for a determination of the type of variability. The shape of the light curve will be a very strong evidence for FUor or UXor type of variability. We'll try to collect more data from the archiving photographic plates and new CCD observations to solve the problem with the exact classification of V733 Cep.

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Table 4. Photometric observations of V733 Cep in the period February 2007 - February 2008

Date	J.D.(245...)	I_c	R_c	V	B	CCD	Tel.
2007 Feb 25	4157.212	14.06	16.35	18.19	–	ST-8	Schmidt
2007 Apr 10	4200.582	14.07	16.04	18.19	–	VersArray	2m RCC
2007 Jun 27	4278.519	14.17	16.41	18.41	21.08	Photometrics	1.3m RC
2007 Jul 04	4285.525	14.11	16.33	18.34	21.08	Photometrics	1.3m RC
2007 Jul 23	4305.494	14.02	16.25	18.22	20.75	ANDOR	1.3m RC
2007 Jul 25	4306.512	14.04	16.27	18.27	20.81	ANDOR	1.3m RC
2007 Aug 14	4327.401	14.07	16.02	18.18	–	VersArray	2m RCC
2007 Aug 15	4328.402	14.09	16.04	18.22	–	VersArray	2m RCC
2007 Aug 17	4330.461	14.10	16.09	18.19	21.01	VersArray	2m RCC
2007 Nov 06	4411.217	14.17	16.12	18.24	–	VersArray	2m RCC
2008 Feb 12	4509.235	14.29	16.25	18.38	–	ST 11000	Schmidt
2008 Feb 29	4526.220	14.19	16.13	18.09	–	ST 11000	Schmidt

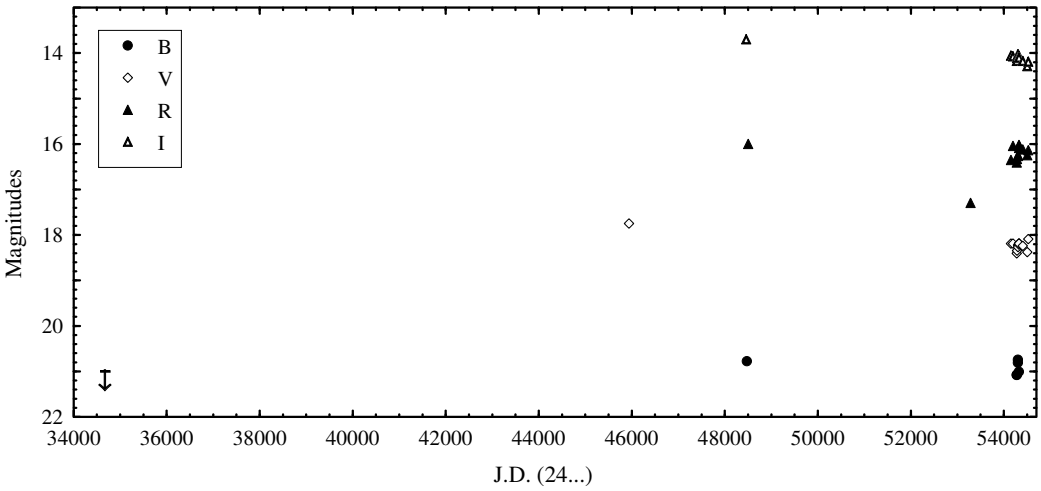

Figure 2. B, V, R_c and I_c light curves of V733 Cep

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