COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 6025

Konkoly Observatory
Budapest
25 June 2012

HU ISSN 0374 – 0676

VR_CI_C OPTICAL LIGHT CURVES OF V1647 Ori DURING THE CONTINUING SECOND OUTBURST

SEMKOV, E. H.; PENEVA, S. P.

Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, 72 Tsarigradsko Shose blvd., BG-1784 Sofia, Bulgaria, e-mail: esemkov@astro.bas.bg, speneva@astro.bas.bg

The outburst of the pre-main sequence (PMS) star V1647 Ori was discovered by the amateur astronomer Jay McNeil in January 2004 (McNeil 2004). The star showed an increase of its optical brightness by around 5 mag beginning from November 2003 till February-March 2004 (Briceño et al. 2004). V1647 Ori remained in a state of maximum light about two years, then its brightness declined to the pre-outburst level (Kóspál et al. 2005). The optical and infrared light curves of V1647 Ori during the outburst are well studied and documented (Acosta-Pulido et al. 2007, Fedele et al. 2007, Aspin & Reipurth 2009, García-Alvarez et al. 2011). During the outburst V1647 Ori exhibited a strong emission spectrum in the optical and near-IR, typical for eruptive PMS stars of EXor type (Herbig 2008). However, the spectral structure in the infrared and the relatively long outburst give some reasons to classify the star as a FUor (Aspin et al. 2008).

A second outburst of the star was registered in 2008, when its brightness increased again to the level of the first eruption (Itagaki et al. 2008, Kun 2008). The optical and infrared follow-up observations show that the star and the surrounding nebula appear photometrically and morphologically similar to the first outburst (Aspin et al. 2009). Only a few papers publishing data from optical and infrared photometric observations during the second outburst have appeared until now (Kaurav et al. 2010, García-Alvarez et al. 2011, Aspin 2011). During both outbursts V1647 Ori showed a strong emission Hα line with blueshifted absorption (P Cygni profile) while in the time between the outburst the Hα line weakened and the blueshifted component disappeared (Aspin & Reipurth 2009, Aspin 2011). A correlation between the X-ray luminosity and I_C magnitude during the two outbursts were found by Teets et al. (2011).

The present paper is a continuation of our photometric study of the star during the first outburst (Semkov 2004, 2006). We present new VR_CI_C photometric data of V1647 Ori in the period November 2008 – April 2012. A part of our data (from 2008 Nov 20 till 2010 Aug 20) are presented in Fig. 1 of García-Alvarez et al. (2011). Our data were obtained in two observatories with three telescopes: the 2-m RCC and the 50/70-cm Schmidt telescopes of the National Astronomical Observatory Rozhen (Bulgaria) and the 1.3-m RC telescope of the Skinakas Observatory of the Institute of Astronomy, University of Crete (Greece). The technical parameters and chip specifications of the CCD cameras

Table 1. CCD cameras and chip specifications

Telescope	CCD type	Size	Pixel size [μm]	Field	RON [ADU/rms]
2-m RCC	VersArray 1300B	1340×1300	20	5′.6×5′.6	2.8
1.3-m RC	ANDOR DZ436-BV	2048×2048	13.5	9′.6×9′.6	5.3
50/70-cm Schmidt	STL-11000M	4008×2672	9	72′×48′	13
50/70-cm Schmidt	FLI PL16803	4096×4096	9	74′×74′	9

used are summarized in Table 1. All frames were taken through a standard Johnson–Cousins set of filters. Aperture photometry was performed using DAOPHOT routines.

The VR_CI_C comparison sequence reported in Semkov (2006) was used as a reference. In order to minimize the light from the surrounding nebula, all frames were reduced using the same aperture of 2″.5 radius and the background was taken between radii 20″ and 25″. The typical errors in the reported magnitudes are in the range $0^m.01$-$0^m.03$ (I and R) and $0^m.02$-$0^m.05$ (V) for observations made with 2-m RCC and 1.3-m RC telescopes and in the range $0^m.02$-$0^m.04$ (I) and $0^m.02$-$0^m.06$ (R) for observations made with the Schmidt telescope. The results from our CCD photometric observations are given in Table 2. The table contains date, the Julian date, the I_C, R_C and V magnitudes. Fig. 1 shows the V, R_C and I_C light curves of V1647 Ori for the period of our photometric observations. Typical error bars for each filter are shown at the left.

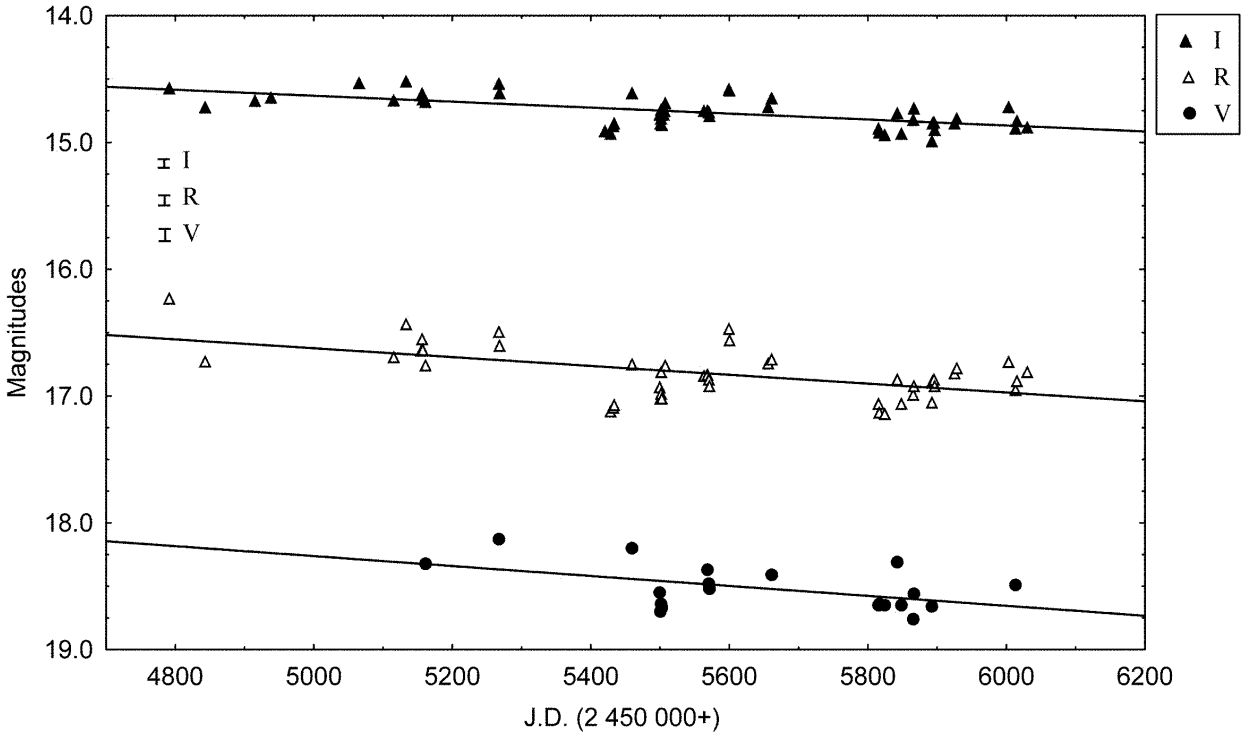

Figure 1. V, R_C and I_C light curves of V1647 Ori

Table 2. Photometric observations of V1647 Ori

Date	J.D.(245...)	I_C	R_C	V	Tel.	CCD
2008 Nov 20	4791.387	14.57	16.23	–	Schmidt	STL11000
2009 Jan 11	4843.263	14.72	16.73	–	Schmidt	STL11000
2009 Mar 24	4915.262	14.67	–	–	Schmidt	STL11000
2009 Apr 16	4938.277	14.65	–	–	Schmidt	STL11000
2009 Aug 21	5065.562	14.53	–	–	Schmidt	FLI
2009 Oct 09	5115.453	14.67	16.69	–	Schmidt	FLI
2009 Oct 28	5133.419	14.52	16.43	–	Schmidt	FLI
2009 Nov 19	5155.411	14.63	16.64	–	Schmidt	FLI
2009 Nov 20	5156.473	14.61	16.55	–	Schmidt	FLI
2009 Nov 21	5157.474	14.66	16.64	–	Schmidt	FLI
2009 Nov 25	5161.497	14.68	16.76	18.32	2m RCC	VA
2010 Mar 11	5267.277	14.54	16.49	18.13	2m RCC	VA
2010 Mar 12	5268.324	14.61	16.60	–	2m RCC	VA
2010 Aug 12	5420.616	14.91	–	–	1.3m RC	ANDOR
2010 Aug 20	5428.613	14.93	17.12	–	1.3m RC	ANDOR
2010 Aug 24	5432.588	14.87	17.09	–	1.3m RC	ANDOR
2010 Aug 25	5433.598	14.85	17.07	–	1.3m RC	ANDOR
2010 Sep 20	5459.639	14.61	16.75	18.20	1.3m RC	ANDOR
2010 Oct 30	5499.526	14.78	16.93	18.55	2m RCC	VA
2010 Oct 31	5500.506	14.85	17.02	18.70	2m RCC	VA
2010 Nov 01	5501.501	14.81	16.98	18.64	2m RCC	VA
2010 Nov 02	5502.571	14.86	17.02	18.67	2m RCC	VA
2010 Nov 04	5505.475	14.78	–	–	Schmidt	FLI
2010 Nov 06	5506.504	14.75	–	–	Schmidt	FLI
2010 Nov 07	5507.514	14.69	16.76	–	Schmidt	FLI
2011 Jan 01	5563.423	14.75	16.84	–	Schmidt	FLI
2011 Jan 06	5568.391	14.75	16.83	18.37	2m RCC	VA
2011 Jan 08	5570.277	14.76	16.87	18.48	2m RCC	VA
2011 Jan 09	5571.381	14.79	16.92	18.52	2m RCC	VA
2011 Feb 06	5599.324	14.58	16.47	–	Schmidt	FLI
2011 Feb 07	5600.302	14.59	16.56	–	Schmidt	FLI
2011 Apr 04	5656.256	14.72	16.74	–	Schmidt	FLI
2011 Apr 09	5661.263	14.65	16.71	18.41	2m RCC	VA
2011 Sep 11	5815.567	14.89	17.06	18.65	1.3m RC	ANDOR
2011 Sep 12	5816.594	14.92	17.13	18.64	1.3m RC	ANDOR
2011 Sep 20	5824.540	14.94	17.14	18.65	1.3m RC	ANDOR
2011 Oct 08	5842.513	14.77	16.87	18.31	1.3m RC	ANDOR
2011 Oct 14	5848.502	14.93	17.06	18.65	1.3m RC	ANDOR
2011 Oct 30	5865.486	14.82	16.99	18.76	2m RCC	VA
2011 Nov 01	5866.530	14.73	16.92	18.56	2m RCC	VA
2011 Nov 26	5892.477	14.99	17.05	18.66	2m RCC	VA
2011 Nov 27	5893.420	14.85	16.88	–	Schmidt	FLI
2011 Nov 29	5895.489	14.84	16.87	–	Schmidt	FLI
2011 Nov 30	5896.445	14.90	16.92	–	Schmidt	FLI
2011 Dec 29	5925.475	14.85	16.82	–	Schmidt	FLI
2012 Jan 01	5928.383	14.81	16.78	–	Schmidt	FLI
2012 Mar 16	6003.261	14.72	16.73	–	Schmidt	FLI
2012 Mar 26	6013.262	14.89	16.95	18.49	2m RCC	VA
2012 Mar 28	6015.312	14.83	16.88	–	2m RCC	VA
2012 Apr 12	6030.270	14.88	16.85	–	Schmidt	FLI

The long-term photometric study of V1647 Ori can be very useful to determine the type of the eruption: FUor or EXor. Our observations suggest that the second outburst of V1647 Ori persists for approximately four years. The photometric data show a continuous slight decrease in brightness during the period of observations. In the meantime the star becomes redder with decreasing of its brightness. Using a linear approximation for our data, we calculated the following values for the rates of decline: $\sim$0.07 mag yr^{-1} for I, $\sim$0.11 mag yr^{-1} for R and $\sim$0.15 mag yr^{-1} for V. Random fluctuations in brightness with amplitudes of few tenths of magnitude and timescales of some days were recorded during the first outburst (see Aspin & Reipurth 2009 and references therein). Such a short time scale variability in brightness is observed during the second outburst.

According to Aspin et al. (2009) the decrease in brightness of V1647 Ori over the period 2006–2008 was caused by reduction of the accretion rate and reformation of dust in the circumstellar environment of the star. Therefore, we observe the same outburst that has slowed down temporarily. Such interpretation of the observational results leads Aspin et al. (2009) to the hypothesis that V1647 Ori is a FUor object. Our data show similar photometric behavior of the star during both outbursts and also support the hypothesis of the FUor nature of V1647 Ori. On the other hand the spectrum of the star during the second outburst remains similar to the spectra of EXor objects (Aspin 2011). Therefore, during the second outburst V1647 Ori continues to show the photometric properties of a FUor and the spectral properties of an EXor.

Acknowledgements: This work was partly supported by grants DO 02-85 and DO 02-273 of the National Science Fund of the Ministry of Education, Youth and Science, Bulgaria. The authors thank the Director of Skinakas Observatory Prof. I. Papamastorakis and Prof. I. Papadakis for the telescope time. This research has made use of NASA's Astrophysics Data System.

References:

Acosta-Pulido, J. A., Kun, M., Ábrahám, P. et al. 2007, *AJ*, **133**, 2020
Aspin, C. 2011, *AJ*, **142**, 135
Aspin, C., Beck, T. L., Reipurth, B. 2008, *AJ*, **135**, 423
Aspin, C., Reipurth, B., Beck, T. L. et al. 2009, *ApJ*, **692**, L67
Aspin, C., Reipurth, B. 2009, *AJ*, **138**, 1137
Briceño, C., Vivas, A. K., Hernandez, J. et al. 2004, *ApJ*, **606**, L123
Fedele, D., van den Ancker, M. E., Petr-Gotzens, M. G., et al. 2007, *A&A*, **472**, 207
García-Alvarez, D., Wright, N. J., Drake, J. J. et al. 2011, *ASP Conference Series*, **448**, 609 (arXiv:1108.0828)
Herbig, G. H. 2008, *AJ*, **135**, 637
Itagaki, K., Nakano, S., Yamaoka, H. 2008, *IAUC*, **8968**
Kaurav, S. S., Ojha, D. K., Ninan, J. P., et al. 2010, *ASI Conference Series*, **1**, 237
Kóspál, A., Ábrahám, P., Acosta-Pulido, J., et al. 2005, *IBVS*, 5661
Kun, M. 2008, *IBVS*, **5850**
McNeil, J. W. 2004, *IAU Circ.*, **8284**
Semkov, E. H. 2004, *IBVS*, **5578**
Semkov, E. H., 2006, *IBVS*, **5683**
Teets, W. K., Weintraub, D. A., Grosso, N., et al. 2011, *ApJ*, **741**, 83