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V2492 Cygni: Optical *BVRI* Variability During the Period 2010−2017

Sunay I. Ibryamov[1,3], Evgeni H. Semkov[2] and Stoyanka P. Peneva[2]

[1]Department of Physics and Astronomy, University of Shumen, 115, Universitetska Str., 9700 Shumen, Bulgaria
[2]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, 72, Tsarigradsko Shose Blvd., 1784 Sofia, Bulgaria
[3]Email: sibryamov@shu.bg

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Abstract

Results from *BVRI* photometric observations of the young stellar object V2492 Cyg collected during the period from August 2010 to December 2017 are presented. The star is located in the field of the Pelican Nebula and it was discovered in 2010 due to its remarkable increase in the brightness by more than 5 mag in *R*-band. According to the first hypothesis of the variability, V2492 Cyg is an FUor candidate. During subsequent observations, it was reported that the star shows the characteristics inherent to EXor- and UXor-type variables. The optical data show that during the whole time of observations the star exhibits multiple large amplitude increases and drops in the brightness. In the beginning of 2017, we registered a significant increase in the optical brightness of V2492 Cyg, which seriously exceeds the maximal magnitudes registered after 2010.

Keywords: stars: individual: (V2492 Cyg) – stars: pre-main sequence

1 INTRODUCTION

During the pre-main sequence (PMS) evolution, the young stellar objects show various types of stellar activity. PMS stars are separated into two main types: low-mass ($M \leqslant 2$ M$_\odot$) T Tauri stars (TTS) and the more massive (2 M$_\odot$ $\leqslant M \leqslant 8$ M$_\odot$) Herbig Ae/Be stars (HAEBES) (Joy 1945; Herbst et al. 1994; Hillenbrand et al. 1992; Petrov 2003). A special kind of variability can be seen in the PMS stars, which undergo outbursts and/or obscurations. The outbursts of the PMS stars—with amplitude reaching up to 5 mag—are grouped into two types: FUors with the prototype FU Orionis (Reipurth & Aspin 2010; Audard et al. 2014) and EXors with the prototype EX Lupi (Herbig 2007; Reipurth & Aspin 2010). Such outbursts are rare occurrences and they are related to PMS stars during their evolutionary state, which ranges from early deeply embedded Class 0/I stage to a late Class II-type object. Theoretical models (see Vorobyov & Basu 2015) predict that after a sequence of eruptions the stars enter a more quiescent phase becoming classical TTS. Also, according to Fehér et al. (2017), FUors might represent the link between Class I and Class II low-mass young stars and the FUor outbursts may play the key role in this transition.

The outbursts of both types of eruptive PMS stars are generally attributed to a sizable increase in the accretion rate from the circumstellar disk onto the stellar surface. In the case of FUors, the accretion rate rapidly increases and remains elevated over several decades or more. EXors exhibit shorter and repetitive outbursts associated with lower accretion rates (Audart et al. 2014). Spectroscopic observations of EX Lupi itself in outbursts and during its quiescence phases revealed that it is an M0 classical TTS that suffers episodes of variable mass accretion (Herbig et al. 2001; Herbig 2007).

The drops in the brightness of the PMS stars with amplitude reaching up to 3 mag in *V*-band are mostly seen in the early types of TTS and in HAEBES (Grinin et al. 1991; Herbst et al. 2007). Such stars are called UXors, named after their prototype UX Orionis. Different members of this group show different photometric activity which can change over time (Zaitseva 1986). It is generally accepted that the observed minima result from the variations in the density of the dust in the orbit around the star, which crosses the line of sight and obscures the star. This idea was first proposed by Wenzel (1969) and then discussed in further research by Grinin (1988), Voshchinnikov (1989), Grinin et al. (1991), Natta & Whitney (2000), and Dullemond et al. (2003).

An important characteristic of UXors is that in their deep minima these objects become bluer—the so-called 'blueing effect' or 'colour reverse' (Bibo & Thé 1990). The interpretation of this effect states that the star is surrounded by circumstellar clouds and/or cometary bodies (Grady et al. 2000).

Table 1. Photometric data for the *BVRI* comparison sequence.

Star	I	σ_I	R	σ_R	V	σ_V	B	σ_B
B	10.741	0.049	12.538	0.020	14.242	0.021	16.877	0.025
C	13.092	0.031	13.925	0.016	14.683	0.016	15.907	0.022
D	13.218	0.028	14.178	0.017	14.968	0.014	16.237	0.015
E	14.161	0.028	14.733	0.016	15.289	0.014	16.241	0.018
F	13.634	0.053	14.792	0.078	15.860	0.091	17.553	0.101
G	15.100	0.037	15.922	0.018	16.809	0.019	18.209	0.031
H	14.646	0.031	15.937	0.021	17.085	0.027	18.915	0.043
I	14.521	0.035	16.028	0.020	17.305	0.033	19.219	0.032
J	15.329	0.033	16.519	0.018	17.510	0.021	19.100	0.067
K	14.536	0.038	16.243	0.022	17.847	0.056	20.249	0.080
L	15.660	0.033	17.027	0.020	18.229	0.037	20.108	0.095

When one of these objects crosses the line of sight, a decrease in star's brightness is observed. Because of the absorption, the star initially becomes redder, but in a large extinction the scattered light from the dust clouds begins to dominate and the star becomes bluer. The interferometric millimetre observations of some UXors and their analysis show that these stars are surrounded by circumstellar disks similar to those around TTS: optically thick with a mass $0.01-0.1\ M_{\odot}$ (Natta et al. 1999). A large number of UXors are found to be HAEBES, but among the low-mass objects also there are representatives exhibiting the characteristics of UXors, for example, see V582 Aur (Semkov et al. 2013) and V350 Cep (Semkov et al. 2017).

Variability of V2492 Cyg (also known as IRAS 20496+4354, PTF 10nvg, and VSX J205126.1+440523) was discovered by Itagaki & Yamaoka (2010). On the basis of the photometric and spectral observations of the object, Covey et al. (2011) concluded that its brightening is indicative of enhanced accretion and outflow similar to the behaviour of V1647 Ori in 2004–2005. According to Aspin (2011), the spectral characteristics of V2492 Cyg during its outburst in 2010 are very similar to those exhibited by EX Lupi during its 2008 outburst, and V1647 Ori during its elevated phase in 2013. Their conclusion is that V2492 Cyg is similar to EX Lupi although apparently significantly younger. Kóspál et al. (2013) concluded that a single physical mechanism is responsible for the brightness changes of the object and the colour variations suggest that the most likely explanation is the changing extinction along the line of sight. Hillenbrand et al. (2013) discussed the object as a possible source exhibiting both accretion- and extinction-driven high-amplitude variability phenomena. Aspin (2011) reported periodicity of ~100 d for V2492 Cyg, while Hillenbrand et al. (2013) found ~220 d quasi-periodic signal from the object.

In this paper, we present our optical *BVRI* observations of V2492 Cyg and discuss its light curves and colour–magnitude diagrams. Using ours and the available archival observations and data in the literature and in the AAVSO database, we built the long-term multicolour photometric light curves of the object.

2 OBSERVATIONS AND CALIBRATION OF THE STANDARD STARS

The photometric *BVRI* observations of V2492 Cyg were carried out with the 2-m Ritchey–Chrétien–Coudé (RCC), the 50/70-cm Schmidt and the 60-cm Cassegrain telescopes administered by Rozhen National Astronomical Observatory in Bulgaria and the 1.3-m Ritchey–Chrétien (RC) telescope administered by Skinakas Observatory[1] in Greece.

Our CCD observations were performed from 2010 August to 2017 December. The technical parameters and specifications for the cameras used, the observational procedure, and the data reduction process are given in Ibryamov, Semkov, & Peneva (2015). All data were analysed using the same aperture, which was chosen to have a 4 arcsec radius, while the background annulus was taken from 9 to 14 arcsec.

A sequence of six comparison stars labelled from A to F in the field of V2492 Cyg was calibrated in the *VRI*-bands by Kóspál et al. (2011). Since these stars are relatively bright and there is no *B*-band—we decided to calibrate new *BVRI* sequence of comparison stars including stars from *B* to *F* of Kóspál et al. (2011). We chose six more single stars in the field of V2492 Cyg and calibrated all of them in the *BVRI*-bands of the standard Johnson–Cousins system. Calibration was made during eight clear nights (2010 August 26, 2011 August 17, 2011 September 10, 2011 September 19, 2012 September 03, 2012 September 09, 2012 September 22, and 2015 August 12) with the 1.3-m RC telescope. Standard stars from Landolt (1992) were used as a reference. Table 1 contains the photometric data for the *BVRI* comparison sequence. The corresponding average errors in the table are also listed. The stars are labelled from *B* to *L* in order of their *V*-band magnitude and retaining the marks from *B* to *F* for the stars from the paper of Kóspál et al. (2011). By comparing our measured magnitudes with those of Kóspál et al. (2011), we get a very good match for *V*- and relatively significant

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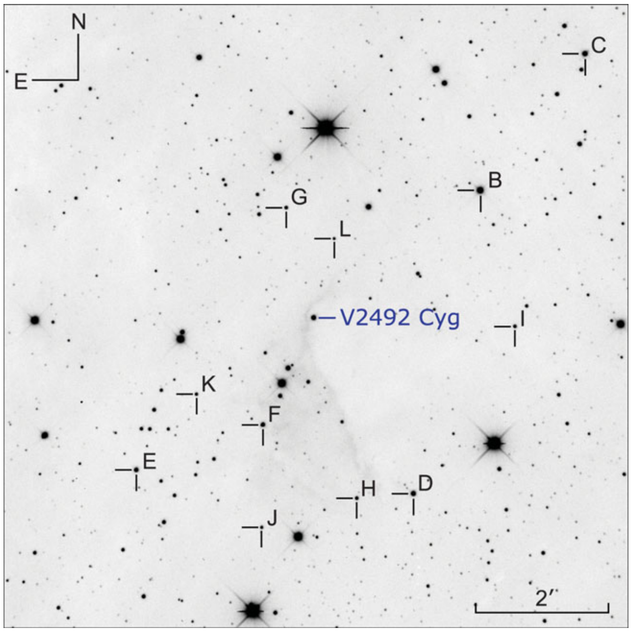

Figure 1. Finding chart for the *BVRI* comparison sequence around V2492 Cyg received in *R*-band with the 1.3-m RC telescope.

differences (0.1–0.2 mag) for *R*- and *I*-band. Due to the relative major errors from measurements of the star *F*, we suspect that it is a possible variable with small amplitude and we advise the observers to use it with discretion.

The chart with the findings of the comparison sequence is presented in Figure 1. The magnitudes of V2492 Cyg from all CCD frames are measured with the standard stars reported in the present paper. The average value of the errors in the reported magnitudes are 0.01−0.02 mag for the *I*- and *R*-band data, 0.01−0.03 mag for the *V*-band data, and 0.02−0.04 mag for the *B*-band data.

3 RESULTS AND DISCUSSION

The optical photometric *BVRI* data of V2492 Cyg received during our photometric monitoring and the ones available in the literature and in the AAVSO database are presented in Figure 2. The results of our CCD observations are summarised in Table A1[2].

It can be seen from Figure 2 that during the period 2010−2017, the object shows strong optical variability: in its light curves, multiple increases and fades are visible, which are with different amplitudes and duration. Several clearly expressed large amplitude increases and deep minima in the star's photometric behaviour can be distinguished. Between these events, the star also shows short increases and drops in the brightness with smaller amplitudes. It should be borne in mind, however, that in a very low light the star's brightness is under the photometric limit of the used telescopes. After 2015 February, a deep minimum in the star's optical light curves is not observed.

Since the beginning of 2015, the brightness of V2492 Cyg began to rise, continuing to the beginning of 2017 when we registered a significant increase in its optical brightness, which seriously exceeds the maximal magnitudes registered after 2010 (reported in Ibryamov & Semkov 2017). The measured maximal values of the star's brightness were B = 15.11 mag, V = 13.52 mag, R = 12.51 mag, and I = 11.37 mag. After our report, Munari et al. (2017) obtained *BVRI* photometry of V2492 Cyg and reported B = 15.68 mag, V = 13.93 mag, R = 12.88, and I = 11.84 mag, i.e. the object passed the recent maximum. Giannini et al. (2018) presented optical and NIR photometric and spectroscopic observations of the star, which were obtained during the peak luminosity in 2016–2017. Their combined analysis suggests that the V2492 Cyg variability is a combination of changing extinction and accretion.

An important result of our study is the change in the colour of V2492 Cyg. Using data from our *BVRI* photometry and the ones available in the literature, three colour–magnitude diagrams ($B - V/V$, $V - R/V$, and $V - I/V$) of the object are constructed and displayed in Figure 3. It can be seen that the star becomes redder when fainter in a manner consistent with the extinction. In accordance with the model of dust clumps obscuration, the observed colour of the star is produced by the scattered light from the small dust grains. Normally, the star becomes redder when its light is covered by dust clumps or filaments in the line of sight. Despite the fact that according to Kóspál et al. (2013), the geometry of the system is closer to edge-on than to pole-on, and the observed fades events with large amplitudes, the blueing effect is not seen in the figure. Most probably, the obscuration does not rise sufficiently for the scattered light to become considerable enough for us to observe the star to become bluer. In this case, the variability of V2492 Cyg is likely dominated by variable accretion, but that does not rule out the obscuration by dust clumps or filaments in the environment of the object, proof of which is the dependence colour/magnitude shown in Figure 3.

The large amplitude outburst peak of V2492 Cyg in 2010, reported by Itagaki & Yamaoka (2010), can only be explained as an episode of enhanced accretion. The registered historical rise in the brightness of the object in the beginning of 2017 may be due to an increase in the accretion rate. Another possible cause is the significant decrease of the extinction from clumps of dust orbiting the star.

We used the software packages PERIOD04 (Lenz & Breger 2005) and PERSEA version 2.6 (written by G. Maciejewski on the ANOVA technique; Schwarzenberg-Czerny 1996) to search for periodicity in the light curves of V2492 Cyg. Initially, we used all data points to search for periodicity in the light curves of the object but we did not find any periodicity. After that, we used data points from different periods of observations for the time-series analysis. Only using the photometric data, received during the period from 2012 July to 2013 November, our time-series analysis indicates a 99-d

[2] The table is available also via CDS VizieR Online Data Catalogue.

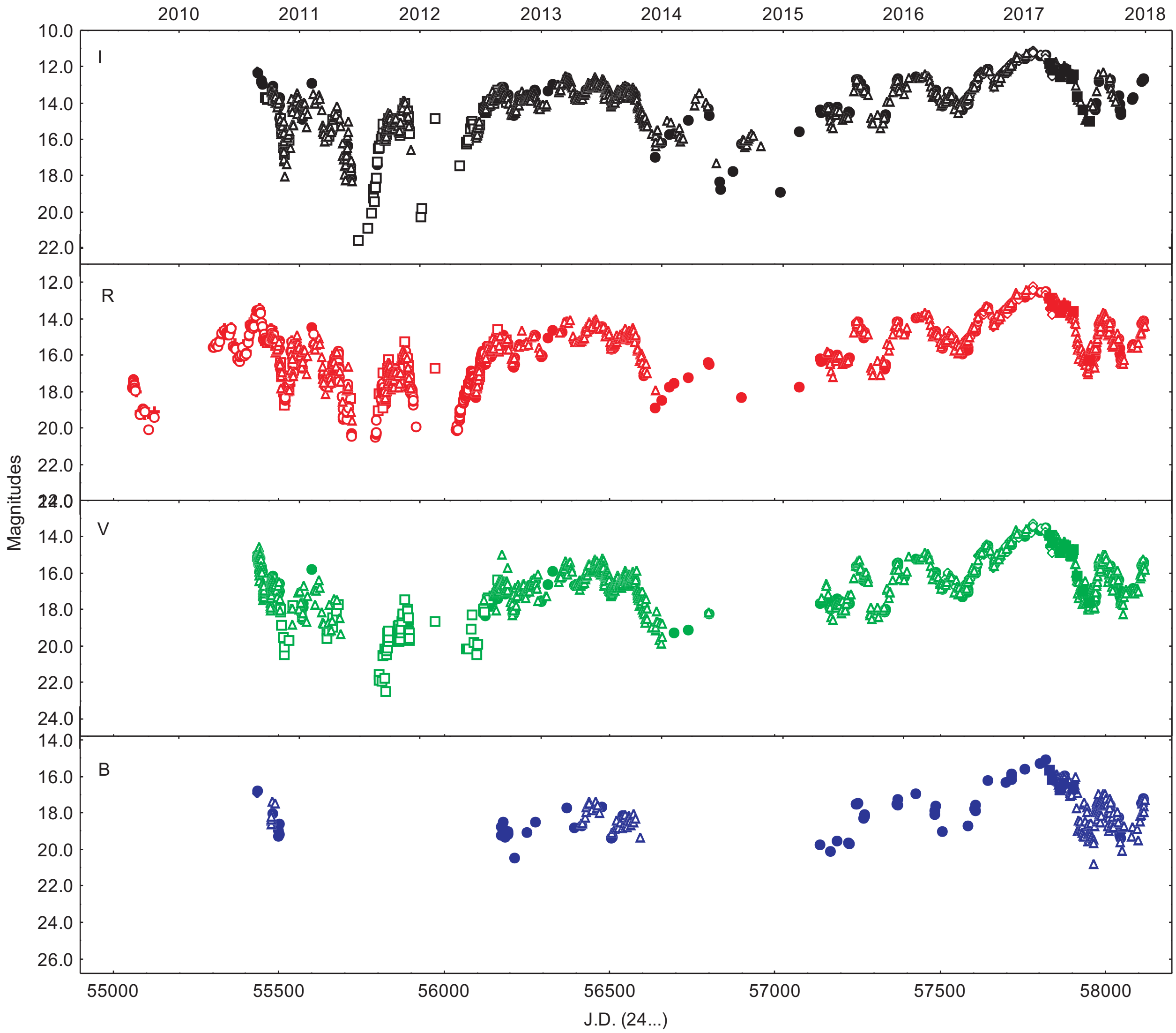

Figure 2. *BVRI* light curves of V2492 Cyg for the period 2010 August−2017 December. The circles denote our CCD photometric data (present paper); the empty triangles represent the data from AAVSO database (http://www.aavso.org); the diamonds represent the photometric data from Munari et al. (2010, 2017); the pluses denote the data from Covey et al. (2011); the empty squares mark the data from Kóspál et al. (2011, 2013); the empty circles represent the data from Hillenbrand et al. (2013); the empty diamonds signify the data from Froebrich et al. (2017); and the squares represent the data from Giannini et al. (2018).

period and led to the ephemeris:

$$JD(Max) = 2456374.998 + 99.099 * E. \tag{1}$$

I-band folded light curve of V2492 Cyg according to the ephemeris (1) is plotted on Figure 4. False Alarm Probability (FAP) estimation was done by randomly deleting about 15% of the data about 50 times and then redetermining the period. The period and starting age determinations remained stable even when a sub-sample of about 20% of the data were removed. The obtained value for FAP is 0.02. The result of our search for periodicity confirms the period of ∼100 d found by Aspin (2011). The reason for not being able to find periodicity using all photometric data is probably hidden in the irrelevant mechanisms (accretion and obscuration) causing changes in the star's brightness in the different time periods, it is also possible the periodicity of the object changes over time.

After analysis of the collected data, our conclusion is that the photometric properties of V2492 Cyg can be explained by superposition of both: (a) variable accretion from the circumstellar disk onto the stellar surface and (b) obscuration from circumstellar clumps of dust. Both types of variability can act independently during different time periods and the result is the complicated light curve of V2492 Cyg. A similar superposition of the both types of variability (accretion and obscuration) is seen on the long-term light curve of other PMS stars—V582 Aurigae (Semkov et al. 2013), V1647 Orionis (Aspin et al. 2009), GM Cephei (Semkov et al.

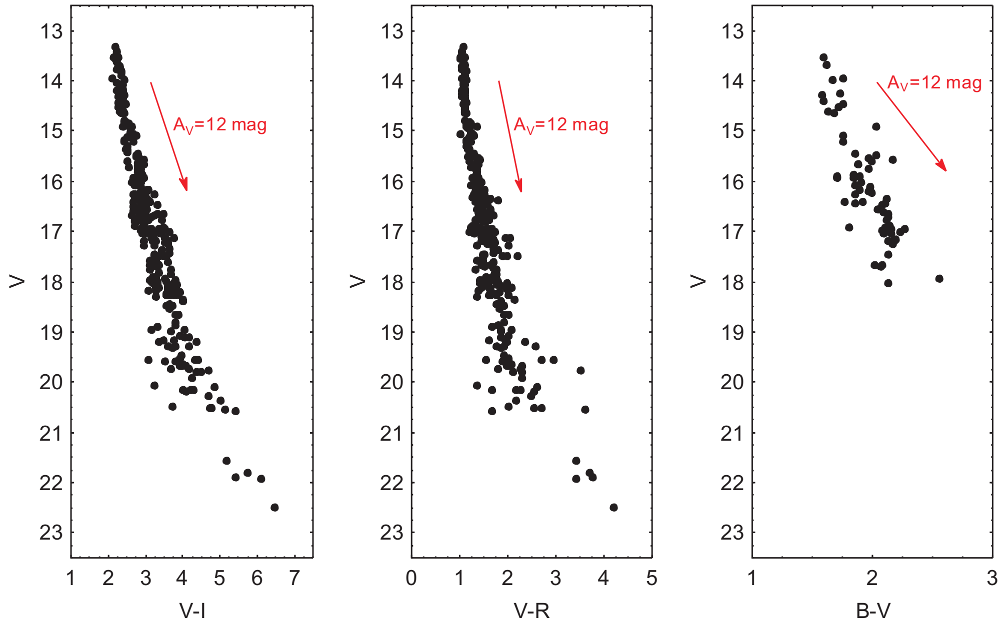

Figure 3. Colour indices $V-I$, $V-R$, and $B-V$ versus the stellar V magnitude of V2492 Cyg. The red line shows the reddening path for $A_V = 12$ mag according to interstellar extinction law from Schlafly & Finkbeiner (2011).

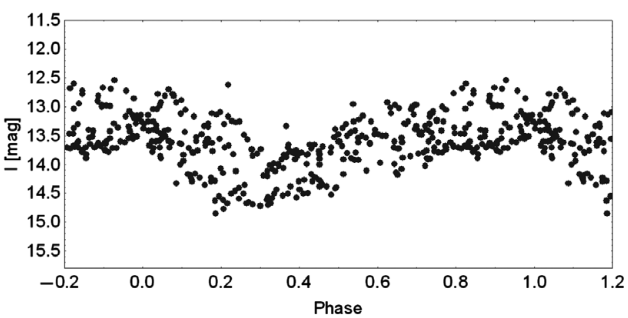

Figure 4. *I*-band folded light curve of V2492 Cyg.

2015a), and V1184 Tauri (Barsunova et al. 2006, Semkov et al. 2015b).

4 CONCLUSION

We built and investigated the long-term *BVRI* photometric light curves of the young stellar object V2492 Cyg during the period from 2010 August to 2017 December. The photometric behaviour of the object, including extreme large amplitudes and rapid variability, can be likely explained by a superposition of both accretion and obscuration events, although their mutual proportion has not been clarified yet. We confirmed the ∼100-d periodicity in the light curves of the object, but it is available only using the photometric data received during the period from 2012 July to 2013 November.

For determining the exact nature of V2492 Cyg further multicolour photometric and spectral observations are of great importance. We plan to continue our photometric monitoring of the object during the next years.

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A *BVRI*-BANDS CCD PHOTOMETRY OF V2492 CYGNI

Table A1. *BVRI*-bands CCD photometry of V2492 Cyg.

Date (DD.MM.YYYY)	J.D. (24...)	*I* [mag]	*R* [mag]	*V* [mag]	*B* [mag]	Tel	CCD
26.08.2010	55435.339	12.35	13.78	15.07	16.82	1.3-m	AND
07.09.2010	55447.457	12.77	14.30	15.64	–	Sch	FLI
08.09.2010	55448.298	12.87	14.40	15.74	–	Sch	FLI
09.09.2010	55449.378	12.98	14.54	15.91	–	Sch	FLI
11.10.2010	55481.316	13.09	14.66	16.17	18.06	1.3-m	AND
29.10.2010	55499.210	14.22	15.73	17.17	19.30	2-m	VA
30.10.2010	55500.184	14.00	15.49	16.89	18.99	2-m	VA
31.10.2010	55501.178	13.71	15.27	–	–	Sch	FLI
31.10.2010	55501.253	13.73	15.23	16.56	18.60	2-m	VA
01.11.2010	55502.178	14.11	15.61	17.01	19.16	2-m	VA
02.11.2010	55503.188	14.85	16.57	–	–	Sch	FLI
03.11.2010	55504.219	14.97	16.76	–	–	Sch	FLI
04.11.2010	55505.175	14.94	16.66	–	–	Sch	FLI
05.11.2010	55506.206	14.82	16.52	17.94	–	Sch	FLI
06.11.2010	55507.207	15.34	17.10	–	–	Sch	FLI
01.01.2011	55563.188	14.17	16.12	–	–	Sch	FLI
06.01.2011	55568.169	14.66	16.47	18.21	–	2-m	VA
08.01.2011	55570.171	14.91	16.72	18.53	–	2-m	VA
09.01.2011	55571.173	14.82	16.70	18.44	–	2-m	VA
11.01.2011	55573.215	14.70	16.22	17.88	–	2-m	VA
12.01.2011	55574.240	14.32	16.01	17.65	–	2-m	VA
07.02.2011	55599.675	12.94	14.48	15.81	–	Sch	FLI
04.04.2011	55656.484	15.50	–	–	–	Sch	FLI
08.04.2011	55659.502	15.63	17.53	–	–	2-m	VA
23.05.2011	55705.398	17.08	–	–	–	Sch	FLI
25.05.2011	55707.379	16.39	–	–	–	Sch	FLI

Table A1. Continued

Date (DD.MM.YYYY)	J.D. (24...)	*I* [mag]	*R* [mag]	*V* [mag]	*B* [mag]	Tel	CCD
08.06.2011	55721.357	18.12	20.30	–	–	2-m	VA
16.08.2011	55790.302	18.38	–	–	–	1.3-m	AND
17.08.2011	55791.306	18.49	–	–	–	1.3-m	AND
23.08.2011	55797.310	17.40	–	–	–	Sch	FLI
10.09.2011	55815.428	15.34	18.11	–	–	1.3-m	AND
11.09.2011	55816.415	15.38	18.20	20.36	–	1.3-m	AND
19.09.2011	55824.258	15.92	18.67	–	–	1.3-m	AND
23.09.2011	55828.268	15.25	–	–	–	Sch	FLI
07.10.2011	55842.288	15.36	17.48	–	–	1.3-m	AND
13.10.2011	55848.252	15.31	17.69	19.77	–	1.3-m	AND
29.10.2011	55864.210	15.72	17.62	19.65	–	2-m	VA
31.10.2011	55866.256	15.73	17.67	19.65	–	2-m	VA
26.11.2011	55892.192	15.01	16.88	18.78	–	2-m	VA
29.11.2011	55895.188	15.51	17.68	–	–	Sch	FLI
30.11.2011	55896.201	15.63	17.89	–	–	Sch	FLI
15.06.2012	56094.409	15.84	17.89	20.13	–	2-m	VA
17.06.2012	56096.374	15.82	18.35	–	–	Sch	FLI
11.07.2012	56120.350	14.17	16.24	17.94	–	Sch	FLI
12.07.2012	56121.313	14.22	16.30	18.05	–	Sch	FLI
13.07.2012	56122.375	14.27	16.38	18.18	–	Sch	FLI
14.07.2012	56123.347	14.36	16.50	18.36	–	Sch	FLI
01.08.2012	56141.399	13.99	15.90	17.59	–	1.3-m	AND
02.08.2012	56142.285	14.18	16.10	17.84	–	1.3-m	AND
03.08.2012	56143.269	14.09	15.98	17.74	–	1.3-m	AND
12.08.2012	56151.614	13.71	15.54	17.22	–	1.3-m	AND
19.08.2012	56159.326	13.68	15.59	17.25	–	Sch	FLI
20.08.2012	56160.303	13.63	15.56	17.22	–	Sch	FLI
21.08.2012	56160.540	13.61	15.48	17.20	–	1.3-m	AND
21.08.2012	56161.323	13.78	15.74	17.42	–	Sch	FLI
22.08.2012	56162.315	13.70	15.65	17.33	–	Sch	FLI
02.09.2012	56173.310	13.35	15.26	16.99	19.21	1.3-m	AND
03.09.2012	56174.274	13.15	15.01	16.63	18.75	1.3-m	AND
07.09.2012	56178.280	13.15	14.90	16.46	18.53	1.3-m	AND
08.09.2012	56179.449	13.26	15.06	16.67	–	1.3-m	AND
09.09.2012	56180.281	13.33	15.14	16.75	18.86	1.3-m	AND
10.09.2012	56181.267	13.46	15.29	16.94	19.08	1.3-m	AND
11.09.2012	56182.222	13.43	15.29	16.93	19.08	1.3-m	AND
12.09.2012	56183.346	13.59	15.47	17.15	19.34	1.3-m	AND
22.09.2012	56193.254	13.56	15.36	16.95	19.03	1.3-m	AND
22.09.2012	56193.317	13.56	15.36	16.92	19.18	Sch	FLI
23.09.2012	56194.301	13.63	15.45	17.03	19.12	Sch	FLI
07.10.2012	56208.229	14.62	16.62	18.26	–	Sch	FLI
08.10.2012	56209.232	14.68	16.66	18.26	–	Sch	FLI
09.10.2012	56210.214	14.51	16.48	18.09	–	Sch	FLI
11.10.2012	56212.241	14.54	16.50	18.14	–	60-cm	FLI
13.10.2012	56214.223	14.39	16.16	17.91	20.46	2-m	VA
25.10.2012	56226.298	13.60	15.40	16.93	–	Sch	FLI
26.10.2012	56227.406	13.68	15.46	17.00	–	Sch	FLI
17.11.2012	56249.191	13.60	15.49	17.11	–	Sch	FLI
18.11.2012	56250.201	13.54	15.38	16.95	19.08	Sch	FLI
12.12.2012	56274.189	13.29	14.88	16.36	–	2-m	VA
14.12.2012	56276.191	13.38	14.93	16.42	18.52	2-m	VA
31.12.2012	56293.225	14.23	16.01	17.49	–	Sch	FLI
01.01.2013	56294.205	14.28	16.09	17.56	–	60-cm	FLI
03.01.2013	56296.253	14.15	16.02	–	–	60-cm	FLI
19.01.2013	56312.197	13.34	15.05	16.63	–	2-m	VA
05.02.2013	56329.182	12.96	14.61	15.91	–	Sch	FLI
06.03.2013	56357.621	13.04	14.75	16.25	–	60-cm	FLI
18.03.2013	56369.585	12.63	14.17	15.57	17.73	2-m	VA
12.04.2013	56394.505	13.56	15.27	16.69	18.81	Sch	FLI
04.05.2013	56417.438	13.66	15.22	16.60	18.69	2-m	VA

Table A1. Continued

Date (DD.MM.YYYY)	J.D. (24...)	*I* [mag]	*R* [mag]	*V* [mag]	*B* [mag]	Tel	CCD
15.05.2013	56428.423	13.26	14.81	16.24	–	60-cm	FLI
17.05.2013	56430.426	–	14.63	–	–	60-cm	FLI
30.05.2013	56443.403	13.00	14.56	15.91	17.75	Sch	FLI
31.05.2013	56444.375	12.97	14.50	15.85	17.69	Sch	FLI
04.07.2013	56478.389	12.98	14.42	15.74	17.70	2-m	VA
01.08.2013	56506.376	14.02	15.68	17.23	19.39	2-m	VA
02.08.2013	56507.386	13.98	15.62	17.18	19.36	2-m	VA
03.08.2013	56508.395	13.99	15.63	17.17	19.33	2-m	VA
04.08.2013	56509.310	13.92	15.63	17.17	–	Sch	FLI
05.08.2013	56510.365	13.87	15.62	17.07	–	Sch	FLI
05.08.2013	56510.392	13.84	15.56	17.01	–	60-cm	FLI
06.08.2013	56511.432	13.77	15.49	17.01	–	60-cm	FLI
07.08.2013	56512.379	13.81	15.57	17.03	–	Sch	FLI
07.08.2013	56512.423	13.78	15.51	16.99	–	60-cm	FLI
08.08.2013	56513.401	13.85	15.57	16.94	–	60-cm	FLI
09.08.2013	56514.369	13.80	15.50	16.94	–	60-cm	FLI
04.09.2013	56540.298	13.29	14.96	16.38	18.29	Sch	FLI
05.09.2013	56541.292	13.26	14.95	16.38	18.14	Sch	FLI
07.09.2013	56543.426	13.34	14.89	16.35	18.46	2-m	VA
08.09.2013	56544.280	13.48	15.05	16.48	–	2-m	VA
11.09.2013	56547.408	13.11	14.74	16.15	–	60-cm	FLI
17.09.2013	56553.262	13.46	15.16	16.67	–	1.3-m	AND
11.10.2013	56577.327	13.59	15.19	16.57	–	60-cm	FLI
12.10.2013	56578.352	13.53	15.13	16.54	–	60-cm	FLI
07.11.2013	56604.286	15.27	17.11	–	–	60-cm	FLI
09.12.2013	56636.209	17.00	18.91	–	–	2-m	VA
29.12.2013	56656.202	16.22	18.46	–	–	Sch	FLI
23.01.2014	56681.208	15.74	17.74	–	–	Sch	FLI
06.02.2014	56694.641	15.70	17.54	19.28	–	2-m	VA
22.03.2014	56738.568	14.93	17.25	19.10	–	Sch	FLI
21.05.2014	56799.450	14.34	16.40	–	–	Sch	FLI
23.05.2014	56801.411	14.70	16.51	18.26	–	2-m	VA
23.06.2014	56832.439	18.37	–	–	–	2-m	VA
25.06.2014	56834.400	18.75	–	–	–	2-m	VA
03.08.2014	56873.383	17.77	–	–	–	2-m	VA
29.08.2014	56899.292	16.24	18.33	–	–	1.3-m	AND
24.12.2014	57016.190	18.92	–	–	–	2-m	VA
21.02.2015	57074.619	15.60	17.77	–	–	Sch	FLI
23.04.2015	57136.465	14.40	16.19	17.68	19.74	Sch	FLI
25.04.2015	57138.472	14.54	16.36	–	–	Sch	FLI
18.05.2015	57161.391	14.22	15.96	17.45	–	Sch	FLI
21.05.2015	57164.440	14.60	16.36	17.88	–	Sch	FLI
24.05.2015	57167.386	14.83	16.46	18.00	20.13	2-m	VA
13.06.2015	57187.356	14.21	15.97	17.43	19.55	2-m	VA
16.07.2015	57220.341	14.64	16.43	17.73	–	Sch	FLI
17.07.2015	57221.393	14.47	16.22	17.57	–	Sch	FLI
19.07.2015	57223.366	14.55	16.19	17.64	19.65	2-m	VA
20.07.2015	57224.394	14.52	16.13	17.64	19.71	2-m	VA
11.08.2015	57246.372	12.71	14.26	15.64	17.52	1.3-m	AND
12.08.2015	57247.299	12.70	14.28	15.66	17.54	1.3-m	AND
17.08.2015	57252.305	12.72	14.15	15.52	17.48	2-m	VA
24.08.2015	57259.466	13.11	14.69	–	–	Sch	FLI
25.08.2015	57260.364	12.92	14.51	–	–	Sch	FLI
03.09.2015	57269.350	13.44	15.03	16.43	18.28	Sch	FLI
04.09.2015	57270.433	13.33	14.87	16.19	18.15	2-m	VA
05.09.2015	57271.411	13.34	14.83	16.22	18.21	2-m	VA
06.09.2015	57272.406	13.25	14.74	16.09	18.07	2-m	VA
03.11.2015	57330.215	14.90	16.76	18.15	–	Sch	FLI
04.11.2015	57331.201	14.83	16.64	18.09	–	Sch	FLI
05.11.2015	57332.204	14.79	16.61	18.04	–	Sch	FLI
06.11.2015	57333.202	14.72	16.60	18.02	–	Sch	FLI
07.11.2015	57334.199	14.66	16.51	17.98	–	Sch	FLI

Table A1. Continued

Date (DD.MM.YYYY)	J.D. (24...)	*I* [mag]	*R* [mag]	*V* [mag]	*B* [mag]	Tel	CCD
12.12.2015	57369.186	12.74	14.19	15.48	17.50	2-m	VA
13.12.2015	57370.163	12.75	14.21	15.60	17.59	2-m	VA
14.12.2015	57371.177	12.77	14.24	15.50	–	2-m	VA
15.12.2015	57372.193	12.67	14.16	15.44	17.29	Sch	FLI
02.01.2016	57390.173	13.20	14.83	16.19	–	Sch	FLI
07.02.2016	57426.188	12.55	13.98	15.20	16.95	Sch	FLI
04.04.2016	57483.498	13.54	14.96	16.24	18.09	2-m	VA
06.04.2016	57484.539	13.38	14.83	16.06	17.91	2-m	VA
06.04.2016	57485.499	13.27	14.69	15.93	17.63	Sch	FLI
27.04.2016	57506.420	14.17	15.62	16.88	19.02	Sch	FLI
13.05.2016	57522.406	13.60	15.06	16.30	–	Sch	FLI
14.05.2016	57523.408	13.37	14.80	16.08	–	Sch	FLI
31.05.2016	57540.384	13.89	15.37	–	–	2-m	VA
25.06.2016	57565.442	14.36	15.93	17.28	–	Sch	FLI
11.07.2016	57581.363	13.89	15.53	16.85	–	Sch	FLI
12.07.2016	57582.391	13.96	15.59	16.89	18.69	Sch	FLI
13.07.2016	57583.377	14.05	15.73	17.02	–	Sch	FLI
01.08.2016	57602.356	13.04	14.57	15.89	17.78	2-m	VA
04.08.2016	57605.360	13.14	14.67	16.00	17.90	Sch	FLI
05.08.2016	57606.353	13.07	14.58	15.89	17.59	Sch	FLI
11.09.2016	57643.261	12.16	13.39	14.50	16.21	Sch	FLI
02.10.2016	57664.230	–	14.32	15.49	–	Sch	FLI
05.11.2016	57698.260	12.21	13.49	14.63	16.31	Sch	FLI
21.11.2016	57714.222	11.89	13.21	14.25	15.97	2-m	VA
22.11.2016	57715.204	11.87	13.16	14.27	15.85	2-m	VA
23.11.2016	57716.215	11.97	13.38	14.44	16.19	2-m	VA
02.01.2017	57756.202	11.54	12.83	13.96	15.62	Sch	FLI
17.02.2017	57801.603	11.40	12.57	13.67	15.28	Sch	FLI
05.03.2017	57817.549	11.37	12.51	13.52	15.11	Sch	FLI
02.04.2017	57845.538	12.28	13.50	14.61	16.24	Sch	FLI
03.04.2017	57846.567	12.09	13.29	14.38	15.97	Sch	FLI
01.05.2017	57875.483	12.10	13.38	14.43	15.96	2-m	VA
18.05.2017	57892.420	12.58	13.85	15.01	16.75	Sch	FLI
19.05.2017	57893.422	12.42	13.75	14.83	16.37	2-m	VA
01.08.2017	57967.382	14.37	16.11	17.55	–	Sch	FLI
02.08.2017	57968.322	14.18	15.94	17.43	–	Sch	FLI
03.08.2017	57969.336	14.03	15.76	17.26	–	Sch	FLI
12.08.2017	57978.495	12.79	14.31	15.61	17.51	Sch	FLI
14.09.2017	58011.268	13.07	14.68	16.08	18.08	Sch	FLI
15.09.2017	58012.286	12.69	14.23	15.58	17.60	Sch	FLI
16.09.2017	58013.269	12.77	14.34	15.71	17.69	Sch	FLI
12.10.2017	58039.223	13.59	15.11	16.39	18.27	Sch	FLI
14.10.2017	58041.398	14.07	15.61	16.95	18.94	2-m	VA
16.10.2017	58043.234	14.39	15.95	17.24	19.12	Sch	FLI
16.10.2017	58043.272	14.39	15.92	17.27	19.23	2-m	VA
17.10.2017	58044.295	14.48	16.09	17.39	19.41	Sch	FLI
18.10.2017	58045.385	14.62	16.23	17.70	–	Sch	FLI
22.11.2017	58080.245	13.81	15.53	16.99	–	Sch	FLI
23.11.2017	58081.257	13.71	15.40	16.85	–	Sch	FLI
21.12.2017	58109.266	12.79	14.29	15.59	17.49	Sch	FLI
25.12.2017	58113.189	12.68	14.12	15.36	17.21	Sch	FLI
26.12.2017	58114.223	12.72	14.19	15.50	17.32	Sch	FLI