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The FUor Star V2493 Cyg (HBC 722)—Eleven Years at Maximum Brightness

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Abstract: At the time of stellar evolution, young stellar objects go through processes of increased activity and instability. Star formation takes place in several stages during which the star accumulates enough mass to initiate thermonuclear reactions in the nucleus. A significant percentage of the mass of Sun-like stars accumulates during periods of increased accretion known as FUor outbursts. Since we know only about two dozen stars of this type, the study of each new object is very important for our knowledge. In this paper, we present data from photometric monitoring on a FUor object V2493 Cyg discovered in 2010. Our data were obtained in the optical region with BVRI Johnson–Cousins set of filters during the period from November 2016 to February 2021. The results of our observations show that during this period no significant changes in the brightness of the star were registered. We only detect variations with a small amplitude around the maximum brightness value. Thus, since 2013 V2493 Cyg remains at its maximum brightness, without a decrease in brightness. Such photometric behavior is not typical of other stars from FUor type. Usually, the light curves of FUors are asymmetrical, with a very rapid rise and gradual decline of the brightness. V2493 Cyg remains unique in this respect with a very rapid rise in brightness and prolonged retention in maximum light. Our period analysis made for the interval February 2013–February 2021 reveals a well-defined period of 914 ± 10 days. Such periodicity can be explained by dust structures remaining from star formation in orbit around the star.

Keywords: stars: pre-main sequence; stars: variables: T Tauri, Herbig Ae/Be; stars: individual: V2493 Cyg

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1. Introduction

The main characteristic of the young stellar objects is their photometric and spectral variability. In fact, most of the pre-main sequence (PMS) stars show variations in brightness that are associated with the evolutionary processes. Most often the variability is observed as transient increases in brightness, outbursts, temporary drops in brightness (eclipses), irregular or regular variations for a short or long time scales. Stars that undergo episodic outbursts with large amplitudes can be divided into two types FUors and EXors [1]. These two types of eruptive stars seem to be related to the low-mass PMS objects (T Tauri stars), which have massive circumstellar disks [2–4].

One of the most remarkable phenomenon in the early stages of stellar evolution is the FUor outbursts. The prototype of FUors is the eruptive star FU Orionis, located in the Orion star forming region. The star was brightened by 6 magnitudes in 1936 and for a long time was the only one object of its kind [5]. First Ambartsumian [6] draws attention to this object by linking it to the evolution of the young stellar objects and proposes the abbreviation FUor. FUors were defined as a class of young variables by Herbig [2] after the discovery of two new FUor objects: V1057 Cyg and V1515 Cyg. About twenty new FUor objects were assigned to this class of young eruptive stars over the next four decades [4,7,8]. Due to the very small number of known FUor objects, each newly discovered attracts significant attention.

All known FUors share the same defining characteristics: location in star-forming regions, outburst with an amplitude of about 4–6 magnitudes, association with reflection nebulae, an F-G supergiant spectrum during the outburst, a strong Li I 6707 Å line in absorption, and CO bands in near-infrared spectra [2,4]. During the outbursts, FUor objects undergo significant increase in their accretion rate from ~$10^{-7} M_{\odot}$/yr up to ~$10^{-4} M_{\odot}$/yr. A typical outburst of FUor objects can last for several decades or a century, and the rise time is usually shorter than that of the decline.

The triggering mechanism of this enhanced accretion rate is carried out by changes in the structure and mass of the circumstellar disk or in the stellar environment. The most popular is that the outburst is caused by gravitational or thermal instability in the circumstellar disk [3,9]. Another possible triggering mechanisms could be the interactions of the circumstellar disk with a planet or nearby stellar companion on an eccentric orbit [10–12] and in fall of clumps of material formed by disk fragmentation onto the central star [13,14]. For a period of ~100 years, the circumstellar disk adds ~10^{-2} $M_{\odot}$ onto the central star and ejects ~10% of the accreting material in a high-velocity stellar wind. During the early evolutionary stages of the solar mass stars they probably went through several dozen episodes of such increased accretion. Calculations show that up to 50% of the protostellar mass can be accumulated due to the FUor phenomenon.

The large amplitude outburst of V2493 Cyg was registered in 2010 [15,16]. In a few months, the brightness of the star increases by more than 4 stellar magnitudes in R-band. V2493 Cyg is located in a region of active star formation, the dark clouds (so-called "Gulf of Mexico") between NGC 7000 and IC 5070. Simultaneously with the optical outburst appearance of a small reflection nebula surrounding V2493 Cyg was observed (Figure 1). The eruptive star received designation V2493 Cyg according to the General catalog of variable stars, but it has been known in previous studies as HBC 722, LkH 188-G4 and PTF10qpf [16–18].

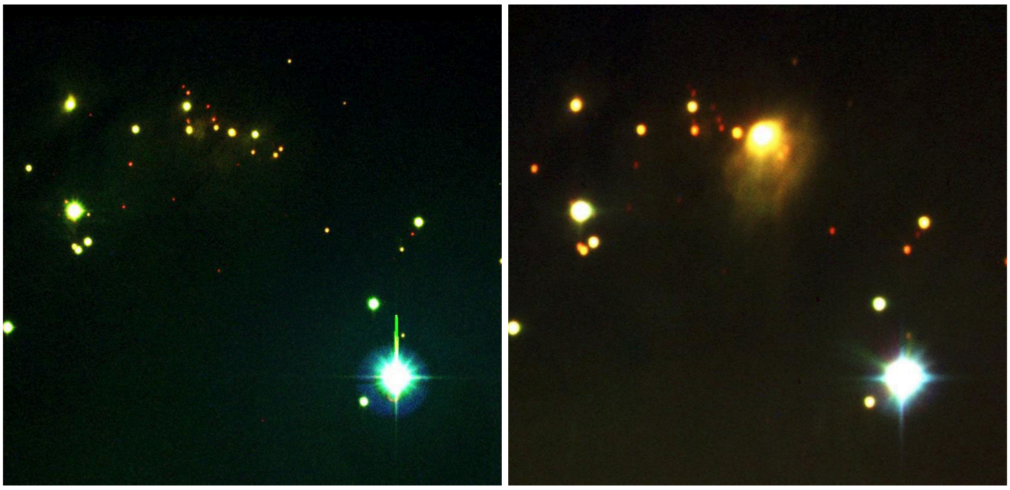

Figure 1. Color images of V2493 Cyg obtained with the 2-m RCC telescope of NAO Rozhen, (**Left**): before the outburst on 16 August 2007, (**Right**): after the outburst on 3 August 2013.

Follow-up photometric observations by Semkov & Peneva [19], Kóspál et al. [20] and Lorenzetti et al. [21] register an ongoing increase in brightness in the optical and near-infrared regions. Significant changes in the profiles and intensity of the spectral lines are registered in high and low resolution spectroscopic observations [15,16,21–25]. Miller et al. [16], Kóspál et al. [20] and Gramajo et al. [26] studied the spectral energy distribution (SED) of the star before and during the eruption. The authors found that prior the outburst V2493 Cyg was a Class II young stellar object (YSO) according to the evolutionary sequence proposed by Adams et al. [27]. The Class II YSOs are most often associated with Classical T Tauri stars, in contrast to the Class I that are younger deeply embedded sources, seen only in the infrared spectral region. The upper limit of the mass of the circumstellar disc has been studied by Dunham et al. [28] and Kóspál et al. [29]. The results indicate that the disk surrounding V2493 Cyg has a relatively low mass (0.01–0.02 $M_{\odot}$) for an object of FUor type. Green et al. [30] have found a 5.8-day and 1.28-day periods in the r-band light curve of the star during several observation sessions in 2011–2012. The first period is explained by the stellar rotation and the second by Keplerian rotation at the inner radius of the accretion disk.

The unusual photometric behavior of V2493 Cyg is also manifested in subsequent observations [29,31–33]. During the period April 2013–October 2016 the star keeps its maximum brightness showing a little bit fluctuations around it. Unlike other known FUor objects, V2493 Cyg reaches maximum brightness, remains in a photometric plateau without evidences of a decrease in brightness. The latest published photometric data on V2493 Cyg confirm the diversity in the light curves of the FUor objects. Our knowledge of the processes occurring during the FUor outbursts is still incomplete and it is necessary to collect more data from regular photometric monitoring of such objects.

2. Observations

The present paper is a continuation of our photometric study of V2493 Cyg before and during the outburst [15,25,32,33]. We present recent $BVRI$ data from photometric observations of the star obtained during the period November 2016–February 2021. The photometric observations of V2493 Cyg were performed with the 2-m Ritchey-Chrétien-Coudé and the 50/70/172 cm Schmidt telescopes of the National Astronomical Observatory Rozhen (Bulgaria). Observations were performed with three types of the CCD camera—Vers Array 1300B and ANDOR iKon-L BEX2-DD at the 2-m RCC telescope, and FLI PL16803 at the 50/70 cm Schmidt telescope. The technical characteristics and optical specifications of the cameras used are listed in Table 1. A standard set of Johnson–Cousins filters were used for all the frames that were obtained. Twilight flat fields in each filter were obtained every clear evening. All frames obtained with the ANDOR and Vers Array cameras are bias subtracted and flat fielded. CCD frames obtained with the FLI PL16803 camera are dark subtracted and flat fielded.

Table 1. CCD cameras used, technical characteristics and optical specifications.

Telescope	CCD Camera Type	Size (px)	Field (arcmin)	Pixel Size (microns)	Scale (″/px)	RON (e^- rms)	Gain (e^-/ADU)
2 m RCC	Vers Array 1300B	1340 × 1300	5.8 × 5.6	20.0	0.26	2.00	1.0
2 m RCC	ANDOR iKon-L	2048 × 2048	6.0 × 6.0	13.5	0.17	6.90	1.1
Schmidt	FLI PL16803	4096 × 4096	73.8 × 73.8	9.0	1.08	9.00	1.0

All the data were analyzed using the same aperture, which was chosen as 4 arc seconds radius. The background annulus is taken from 13 arc seconds to 19 arc seconds in order to minimize the light from the surrounding nebula and avoid contamination from nearby stars. As references, we used the $BVRI$ comparison sequence of fifteen stars in the field around V2493 Cyg published in Semkov et al. [15]. In this way we provided a maximum consistency of the photometric results obtained during the various stages of the photometric observations. The results of our photometric CCD monitoring of V2493 Cyg are summarized in Table 2. The columns provide the date and Julian date (JD) of observation, $IRVB$ magnitudes of V2493 Cyg, the telescope and CCD camera used.

The typical instrumental errors in the reported magnitudes are 0.01 for I and R-band data, 0.01–0.02 for V-band, and 0.01–0.03 for B-band [25]. The typical seeing for the Rozhen observatory is about 2 arc seconds, which is almost always less than the aperture used. Usually, at least two images are obtained every night in each filter and the table shows the average of them. In very few cases, there is a difference in the measured values of the two images, greater than 0.01 mag., which shows the good accuracy of our results.

Table 2. Photometric CCD observations of V2493 Cyg obtained during the period November 2016–February 2021.

Date	JD (24...)	I	R	V	B	Telescope	CCD
5 November 2016	57,698.240	11.30	12.49	13.54	15.09	Sch	FLI
21 November 2016	57,714.254	11.39	12.60	13.65	15.22	2 m	VA
22 November 2016	57,715.227	11.39	12.60	13.68	15.23	2 m	VA
23 November 2016	57,716.245	11.40	12.63	13.72	15.25	2 m	VA
1 January 2017	57,755.211	11.31	12.50	13.54	15.10	Sch	FLI
2 January 2017	57,756.224	11.28	12.44	13.48	15.03	Sch	FLI
28 January 2017	57,782.197	11.34	12.44	13.65	15.13	2 m	VA
30 January 2017	57,784.201	11.23	12.47	13.52	15.09	2 m	VA
31 January 2017	57,785.198	11.26	12.51	13.55	15.11	2 m	VA
1 February 2017	57,786.199	11.27	12.46	13.54	15.06	2 m	VA
17 February 2017	57,801.622	11.29	12.49	13.53	15.07	Sch	FLI
5 March 2017	57,817.575	11.34	12.52	13.57	15.12	Sch	FLI
2 April 2017	57,845.561	11.26	12.45	13.50	15.06	Sch	FLI
3 April 2017	57,846.589	11.27	12.45	13.50	15.05	Sch	FLI
2 May 2017	57,875.503	11.34	12.55	13.61	15.25	2 m	VA
18 May 2017	57,892.397	11.37	12.57	13.61	15.16	Sch	FLI
19 May 2017	57,893.407	11.39	12.61	13.71	15.26	2 m	VA
30 May 2017	57,904.414	11.31	12.48	13.54	15.11	Sch	FLI
12 July 2017	57,947.471	11.24	12.42	13.49	15.05	Sch	FLI
1 August 2017	57,967.414	11.16	12.33	13.39	14.99	Sch	FLI
2 August 2017	57,968.300	11.16	12.35	13.41	15.00	Sch	FLI
3 August 2017	57,969.298	11.19	12.37	13.45	15.05	Sch	FLI
12 August 2017	57,978.471	11.24	12.42	13.49	15.05	Sch	FLI
14 September 2017	58,011.297	11.20	12.41	13.46	15.04	Sch	FLI
15 September 2017	58,012.315	11.19	12.36	13.44	15.01	Sch	FLI
16 September 2017	58,013.301	11.20	12.39	13.45	15.03	Sch	FLI
12 October 2017	58,039.286	11.25	12.46	13.50	15.09	Sch	FLI
14 October 2017	58,041.283	11.26	12.45	13.50		2 m	VA
16 October 2017	58,043.267	11.27	12.49	13.55	15.13	Sch	FLI
16 October 2017	58,043.297	11.30	12.50	13.57	15.11	2 m	VA
17 October 2017	58,044.283	11.31	12.54	13.60	15.17	Sch	FLI
18 October 2017	58,045.380	11.28	12.53	13.59	15.15	Sch	FLI
22 October 2017	58,080.270	11.27	12.48	13.53	15.08	Sch	FLI
23 October 2017	58,081.276	11.26	12.49	13.54	15.11	Sch	FLI
21 December 2017	58,109.298	11.21	12.40	13.46	15.03	Sch	FLI
25 December 2014	58,113.216	11.26	12.48	13.55	15.13	Sch	FLI
26 December 2017	58,114.251	11.27	12.49	13.56	15.12	Sch	FLI
9 April 2018	58,217.594	11.24	12.43	13.49	15.07	Sch	FLI
10 April 2018	58,218.582	11.21	12.41	13.46	15.04	Sch	FLI
12 April 2018	58,220.537	11.18	12.37	13.43	14.98	Sch	FLI
8 June 2018	58,278.415	11.17	12.34	13.41	14.96	Sch	FLI
11 June 2018	58,281.452	11.19	12.38	13.43	14.97	2 m	ANDOR
12 July 2018	58,312.406	11.20	12.39	13.43	14.99	Sch	FLI
16 July 2018	58,316.367	11.24	12.44	13.51	15.08	Sch	FLI
9 August 2018	58,340.357	11.19	12.39	13.47	15.06	Sch	FLI
11 August 2018	58,342.356	11.17	12.37	13.45	15.03	Sch	FLI
12 August 2018	58,343.369	11.14	12.32	13.39	14.97	Sch	FLI
13 August 2018	58,344.348	11.16	12.37	13.45	15.04	Sch	FLI
15 August 2018	58,346.299	11.18	12.40	13.45	15.03	2 m	ANDOR
1 September 2018	58,363.323	11.22	12.41	13.49	15.08	Sch	FLI
2 September 2018	58,364.302	11.22	12.42	13.48	15.06	Sch	FLI
17 October 2018	58,409.267	11.16	12.36	13.44	15.04	Sch	FLI

Table 2. *Cont.*

Date	JD (24…)	I	R	V	B	Telescope	CCD
5 November 2018	58,428.256	11.14	12.34	13.40	14.99	Sch	FLI
12 November 2018	58,435.235	11.17	12.38	13.45	15.04	Sch	FLI
8 January 2019	58,492.201	11.34	12.57	13.66	15.29	Sch	FLI
5 March 2019	58,547.603	11.25	12.45	13.53	15.14	Sch	FLI
29 April 2019	58,603.459	11.31	12.51	13.59	15.20	Sch	FLI
1 May 2019	58,604.511	11.28	12.48	13.56	15.17	Sch	FLI
2 May 2019	58,606.430	11.32	12.51	13.60	15.28	2 m	ANDOR
3 May 2019	58,606.532	11.35	12.57	13.64	15.23	Sch	FLI
30 June 2019	58,665.394	11.28	12.48	13.55	15.15	Sch	FLI
1 July 2019	58,666.411	11.24	12.45	13.54	15.14	Sch	FLI
2 July 2019	58,667.397	11.26	12.49	13.52	15.19	Sch	FLI
25 July 2019	58,690.305	11.30	12.50	13.56	15.24	2 m	ANDOR
26 July 2019	58,691.414	11.32	12.54	13.57	15.21	2 m	ANDOR
27 July 2019	58,692.366	11.28	12.48	13.55	15.19	2 m	ANDOR
8 August 2019	58,704.349	11.28	12.50	13.59	15.21	Sch	FLI
9 August 2019	58,705.378	11.32	12.55	13.63	15.24	Sch	FLI
10 August 2019	58,706.378	11.37	12.61	13.70	15.34	Sch	FLI
11 August 2019	58,707.453	11.34	12.55	13.64	15.29	Sch	FLI
30 August 2019	58,726.344	11.38	12.59	13.64	15.28	2 m	ANDOR
31 August 2019	58,727.382	11.39	12.61	13.68	15.31	2 m	ANDOR
1 September 2019	58,728.423	11.40	12.62	13.74	15.33	2 m	ANDOR
2 September 2019	58,729.336	11.35	12.58	13.68	15.35	2 m	ANDOR
3 September 2019	58,729.540	11.36	12.63	13.73	15.34	Sch	FLI
3 September 2019	58,730.340	11.36	12.61	13.73	15.42	2 m	ANDOR
3 September 2019	58,730.443	11.37	12.66	13.78	15.39	Sch	FLI
1 October 2019	58,758.343	11.38	12.67	13.78	15.40	Sch	FLI
2 October 2019	58,759.331	11.39	12.66	13.77	15.40	Sch	FLI
15 January 2020	58,864.214	11.28	12.42	13.58	15.33	Sch	FLI
16 January 2020	58,865.221	11.28	12.42	13.57	15.29	Sch	FLI
18 January 2020	58,867.184	11.29	12.41	13.55	15.29	2 m	ANDOR
21 January 2020	58,870.213	11.30	12.48	13.63	15.36	Sch	FLI
23 May 2020	58,993.435	11.15	12.29	13.42	15.13	Sch	FLI
9 July 2020	59,040.356	11.17	12.31	13.45	15.16	Sch	FLI
10 July 2020	59,041.391	11.18	12.34	13.47	15.17	Sch	FLI
11 July 2020	59,042.382	11.20	12.36	13.50	15.20	Sch	FLI
28 July 2020	59,059.461	11.09	12.24	13.37	15.07	Sch	FLI
29 July 2020	59,060.369	11.13	12.28	13.40	15.12	Sch	FLI
13 August 2020	59,075.324	11.10	12.31	13.41	15.19	2 m	ANDOR
23 August 2020	59,085.287	11.15	12.34	13.48	15.20	Sch	FLI
8 September 2020	59,101.417	11.11	12.27	13.41	15.13	Sch	FLI
9 September 2020	59,102.337	11.08	12.27	13.35	15.09	2 m	ANDOR
10 September 2020	59,103.346	11.07	12.28	13.37	15.05	2 m	ANDOR
11 September 2020	59,104.380	11.12	12.28	13.42	15.12	Sch	FLI
12 September 2020	59,105.310	11.11	12.28	13.41	15.12	Sch	FLI
15 September 2020	59,108.334	11.12	12.27	13.41	15.10	Sch	FLI
16 September 2020	59,109.306	11.11	12.26	13.40	15.12	Sch	FLI
13 October 2020	59,136.229	11.12	12.31	13.45	15.14	Sch	FLI
23 October 2020	59,146.319	11.14	12.30	13.44	15.15	Sch	FLI
20 November 2020	59,174.225	11.08	12.25	13.37	15.08	Sch	FLI
22 November 2020	59,176.231	11.14	12.30	13.43	15.14	Sch	FLI
23 November 2020	59,177.216	11.13	12.29	13.43	15.12	Sch	FLI
5 January 2021	59,220.184	11.01	12.21	13.34	15.04	2 m	ANDOR

Table 2. *Cont.*

Date	JD (24. . .)	I	R	V	B	Telescope	CCD
4 February 2021	59,250.196	10.96	12.14	13.25	15.06	2 m	ANDOR
5 February 2021	59,251.205	10.90	12.08	13.29	15.08	2 m	ANDOR
12 February 2021	59,258.221	11.05	12.21	13.38		Sch	FLI

3. Results

Data collected from photometric observations of V2493 Cyg show that the outburst registered in 2010 has been going on for at least eleven years. The *BVRI* light-curves of V2493 Cyg during the period June 2008–February 2021 are plotted in Figure 2. The filled diamonds represent our CCD observations (Semkov et al. [15,25,32,33] and the present paper), and the open circles observations from the 48 inch Samuel Oschin telescope at Palomar Observatory [16].

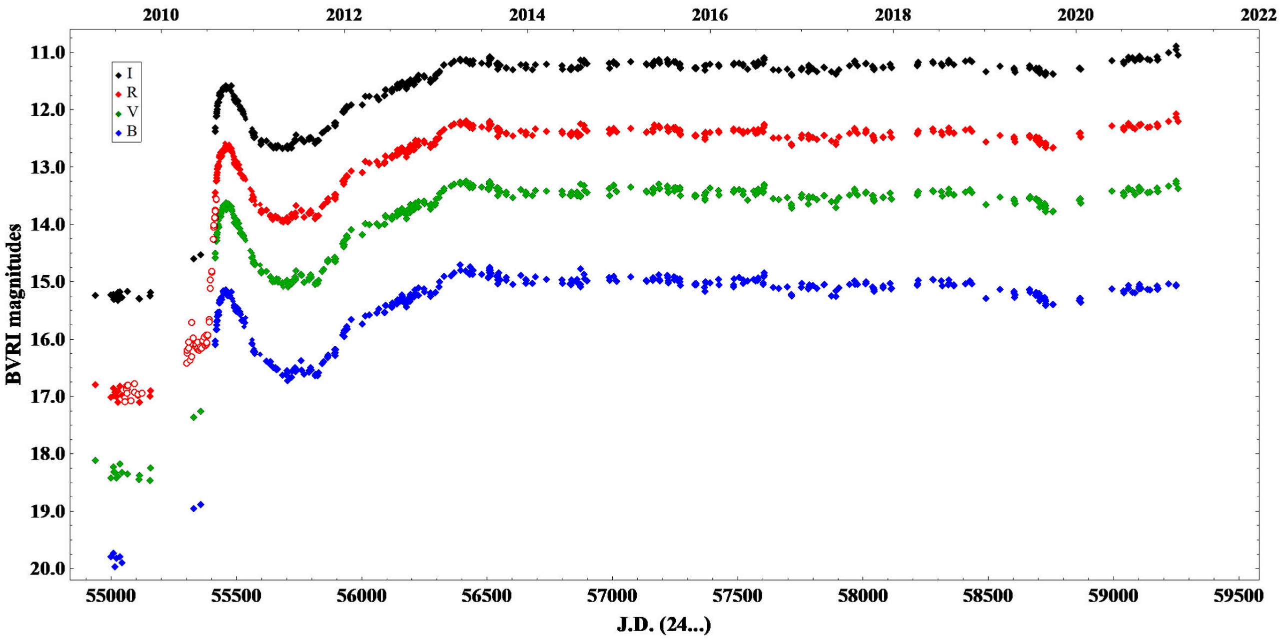

Figure 2. *BVRI* light curves of V2493 Cyg for the period from June 2008 till February 2021.

Our *BVRI* photometric data obtained before the outburst displayed variations with amplitudes less than 1 stellar magnitude in all pass-bands [25]. Such variability is characteristic of weak line T Tauri stars and the most common reason is the rotation of the star with asymmetric distribution of cool spots [34,35]. Data collected by Miller et al. [16] indicate that the outburst began sometime before May 2010, and reached the first maximum in brightness during September–October 2010. Since October 2010, a slow fading was observed and up to May 2011 the star brightness decreased by 1.4 magnitudes in *V*-band. Such a double maximum is not typical for the other FUors. Occasionally, short dips in brightness are observed after the maximum phase, but they are usually caused by the star being obscured by clouds of dust. In the case of V2493 Cyg, the most probable reason for the double maximum is variability in the accretion rate.

During the period from May 2011 till October 2011 no significant changes in the brightness of the star were observed, its brightness remains at 3.3 magnitudes in *V*-band, above the quiescence level. But since the autumn of 2011, another light increase has begun and the star became brighter by 1.8 magnitudes in *V*-band until the spring of 2013. During the period April 2013–February 2021 the star remains at its maximum brightness showing a little bit fluctuations around it.

Simultaneously with the increase in brightness of V2493 Cyg its color changes significantly, the star becomes considerably bluer. While the both color indexes V-I and R-I decreased, the B-V index remained relatively constant before and during the outburst (Figure 3). After six years without changing the values of the color indexes, from 2018 both indexes V-I and R-I show a gradual increase, the star begins to turn red again. This is an evidence of exiting from the maximum phase of the FUor outburst. But we can't rule out new increases in brightness in the future.

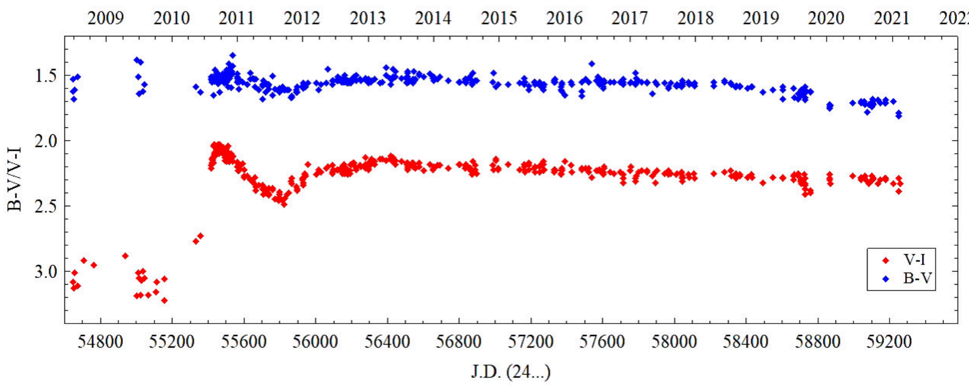

Figure 3. $BVRI$ Color evolution of V2493 Cyg from June 2008 till February 2021.

On the other hand, there is a significant difference in the values of V-I and R-I indexes during the two peaks of brightness (Figure 4). During the first local maximum (August 2010–May 2011) the star was bluer than during the second maximum (June 2011–February 2021). The difference in the V-I indexes at the time of the two peaks in brightness reaches 0.2 magnitudes for the same values of V magnitude. Such a phenomenon can be explained by a gradual expansion of the emitting region around the star.

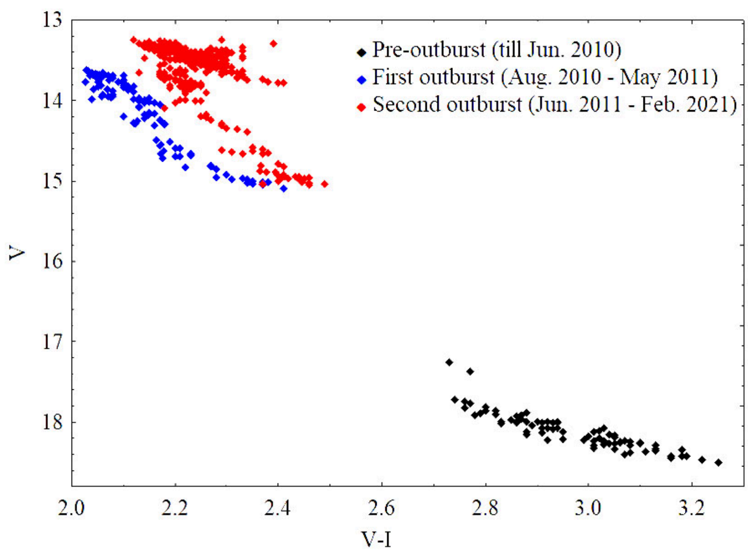

Figure 4. V/V-I diagram from our V and I photometric data.

We carried out a periodicity search in the light variations of V2493 Cyg by the software package Period04 [36]. Such studies are usually severely hampered by the large amplitude photometric variability of the FUors due to the variable accretion rate. In the case of V2493 Cyg, we have been helped by the long photometric plateau during the recent years. Therefore, we considered the star's data received after February 2013, when the brightness of V2493 Cyg varies around some intermediate level in maximal light. Our time-series analysis indicates a 914 $\pm$ 10 day period. The periodogram of the star and its phase-folded V light curve is displayed in Figure 5.

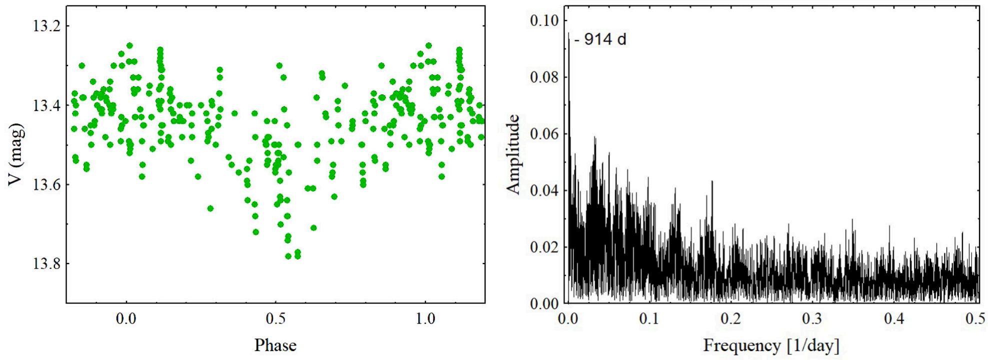

Figure 5. The phase-folded *V* light curve and periodogram of V2493 Cyg for the period February 2013–February 2021.

4. Discussion

V2493 Cyg is one of the few FUor objects for which we have spectral and photometric observations before the outburst. The spectrum of the star before the outburst shows very intense emission lines of hydrogen, and this classifies it as a T Tauri star [15,18]. After the outburst, the spectrum of the star is dominated by absorption lines with strong P Cyg profiles of H-alpha and Na I D lines [16,21–23,25]. The deep and high velocity absorption lines are interpreted as evidence of a strong outflow driven by the central object.

In addition to the 5.8-day and 1.28-day periods discovered by Green et al. [30], we also found a periodicity of 914 $\pm$ 10 days. A similar periodicity of several hundred days was found in the study of the photometric plateau of the FUor object V1057 Cyg [37,38]. In the case of V2493 Cyg we consider that such a periodicity can be explained by dust structures remaining from star formation in orbit around the star. Our arguments for this assumption are that the minimum is relatively narrow and not very deep. A similar effect would be caused by diffuse clouds of dust, which do not have a separate central concentration. The reason for this periodicity cannot be proved by a change in color indices due to the small amplitude. By analogy with other FUors such as V1057 Cyg, it justifies such an assumption.

Over the last thirty years, we have undertaken intensive optical photometric monitoring of some unexplored FUor-type objects [39]. Since these objects are located in the regions of star formation, we have the opportunity to study the photometric behavior of a large number of PMS stars. Our data can also be used to detect new FUor or EXor eruptions, to study the light curve and to classify the observed outburst. FUors and EXors are the most distinguishable young variable objects due to the large amplitudes and eruptions that last for years. Due to the small number of known FUor objects, we do not have sufficient statistics on their photometric evolution during the outburst.

Attempts to classify objects of FUor type on the basis of their photometric properties have so far been unsuccessful. The comparison of the light curves of the known FUor objects shows that they are very different from each other and very rarely recur. Even the first discovered, so-called "classical" FUors (FU Ori, V1057 Cyg and V1515 Cyg) show very different rates of increase and decrease in brightness [37]. The variety of light curves increases even more with the number of well-studied FUor objects. FUors light curves are usually asymmetric, with rapid increases and gradual decreases in brightness. Some objects show a very rapid increase in brightness over several months or a year, such as FU Ori, V1057 Cyg and V2493 Cyg [25,37,40]. In other cases, such as V1515 Cyg, V1735 Cyg, V733 Cep and V900 Mon, the increase in brightness can last for several years and even reach 20–30 years [37,41–43].

A similar variety is observed at the time of decline in brightness. Usually the decline in brightness takes several decades and will probably take up to a century. But there are objects in which a relatively rapid decrease in brightness is observed. For example, V960 Mon, in which the brightness decreases by 2 stellar magnitudes in the *V*-band for a period of about five years [44]. In the case of V582 Aur two deep decreases in brightens by about

3 magnitudes in *R*-band have been observed separated by a five-year period [45,46]. In the case of V582 Aur, two deep declines in brightens of about 3 stellar magnitudes in the *R*-band were observed, five years apart. But there are also objects that for a period of several decades practically do not change their brightness, as in the case of V1735 Cyg [39,41] or Parsamian 21 [39,47]. In this respect, the light curve of the FUor object V733 Cep is unique, which is approximately symmetrical. The rate of increase and the rate of decrease in brightness are almost identical [42]. This diversity of photometric properties strongly supports the suggestion that FUor objects are not a homogeneous group and that the causes of this phenomenon may be several different mechanisms [14].

5. Conclusions

We support the idea that the type of light curve of FUor objects can be evidence of a specific cause of their outburst. Trying to compare the available photometric data for V2493 Cyg with the other FUors, we register the following similarities. The fast rise in brightness for a period of two years is similar to that of the objects FU Ori, V1057 Cyg and V582 Aur. At the same time for more than seven years, the brightness of the object remains constant at the level of the maximum like V1735 Cyg and Parsamian 21. For now, there are no indications of a decrease in brightness like other FUor objects.

The results of our studies show that V2493 Cyg is one of the most interesting FUor objects. V2493 Cyg is the best studied spectroscopically and photometrically FUor object before and after the outburst. During the outburst, the star was observed in a wide range from the far infrared region to X-rays. Our results show the need for systematical photometric monitoring of FUor objects. Continuation of spectral and photometric observations of V2493 Cyg can give us even more important information about the processes of outbursts of FUor type.

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Abbreviations

The following abbreviations are used in this manuscript:

YSO	Young stellar object
PMS	Pre-main sequence
FUor	Object from FU Orionis type
EXor	Object from EX Lupi type
$M_{\odot}$	Solar mass
SED	Spectral energy distribution
NAO	National Astronomical Observatory
JD	Julian date

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