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

Number 5939

Konkoly Observatory
Budapest
17 May 2010

HU ISSN 0374 – 0676

OPTICAL PHOTOMETRY OF PARSAMIAN 21

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

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

One of the most impressive events during the early stages of stellar evolution is the FU Orionis (FUors) outbursts (Herbig, 1977). The main characteristics of FUors are an increase in optical brightness of about 4-5 mag, a F-G supergiant spectrum with broad blueshifted Balmer lines, strong infrared excess, and connection with reflection nebulae. The light curves of FUors are characterized by a rapid rise in brightness to the maximal light (outburst) followed by a relatively slow decrease in brightness after the outburst (Clarke et al., 2005). According to Hartmann & Kenyon (1985) the FUor outburst is a result of a major increase of accretion from a circumstellar disk on the stellar surface.

Parsamian 21 is a young stellar object surrounded by an extended reflection nebula, located in a small dark cloud in Aquila. The object was discovered on the plates from the Palomar Observatory Sky Survey and included in the catalog of cometary nebulae (Parsamian, 1965). On the basis of optical spectroscopic and far-infrared properties Parsamian 21 was classified as a FUor object (Staude & Neckel, 1992). Results supporting the FUor nature of Parsamian 21 were published in Kóspál et al. (2008). Parsamian 21 was a subject of many studies, but very few optical photometric data have been published to the present (Parsamian & Petrosian, 1978, Neckel & Staude, 1984). Since no outburst was observed at optical wavelengths in most of the studies Parsamian 21 is classified as FUor-like object (Greene et al., 2008).

In this paper we present $BVRI$ photometric data of Parsamian 21 obtained in the period Feb. 2003 - Jul. 2009. Our observations were performed with two telescopes: the 2-m RCC telescope of the National Astronomical Observatory Rozhen (Bulgaria) and the 1.3-m RC telescope of the Skinakas Observatory[1] of the Institute of Astronomy, University of Crete (Greece). Three 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. The procedure used calculate the centroid of stellar object and the mean value of the background around it. The digitized plates from the Palomar Schmidt telescope, available via the website of the Space Telescope Science Institute, are used, too.

In order to facilitate transformation from instrumental measurements to the standard system a sequence of sixteen comparison stars in the field of Parsamian 21 was calibrated in $BVRI$ bands. Calibrations were made with the 1.3 m RC telescope during nine clear

[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.

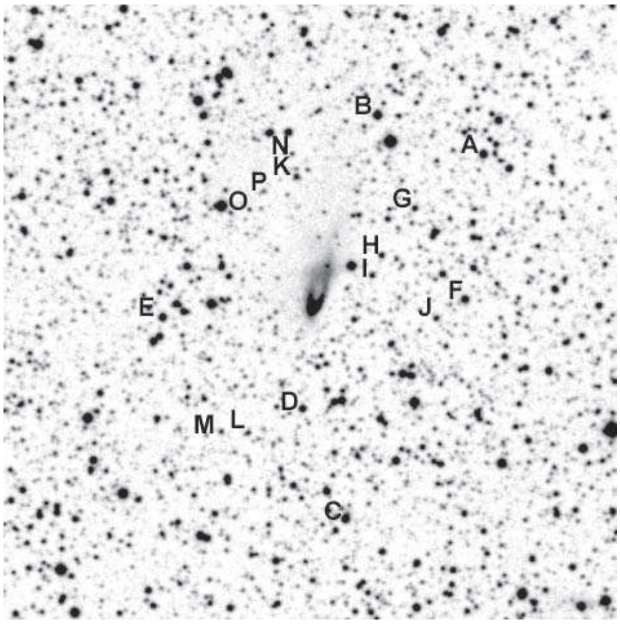

Figure 1. A finding chart of the comparison sequence in the field of Parsamian 21

Table 1. CCD cameras and chip specifications

Telescope	CCD type	Size	Pixel size	Field	RON
2-m RCC	Photometrics AT200	1024×1024	24μm	$5\overset{\prime}{.}6 \times 5\overset{\prime}{.}6$	3.9ADU/rms
1.3-m RC	Photometrics CH360	1024×1024	24μm	$8\overset{\prime}{.}5 \times 8\overset{\prime}{.}5$	2.6ADU/rms
1.3-m RC	ANDOR DZ436-BV	2048×2048	13.5μm	$9\overset{\prime}{.}6 \times 9\overset{\prime}{.}6$	5.3ADU/rms

nights in 2007, 2008 and 2009. Standard stars from Landolt (1992) were used as a reference. The finding chart of the comparison sequence is presented in Fig. 1. The chart is retrieved from the STScI Digitized Sky Survey Second Generation Red. The field is $8\overset{\prime}{.}0 \times 8\overset{\prime}{.}0$, centered on Parsamian 21. North is at the top and east to the left. Table 2 contains the coordinates and the photometric data for the $BVRI$ comparison sequence. The corresponding mean errors of the mean are listed, too. The comparison sequence contains stars both redder and bluer than Parsamian 21, labeled from A to P in order of their V-band magnitude.

The results from our CCD photometric observations are given in Table 3. The table contains Date, the Julian Date, the Ic, Rc, V and B magnitudes. In order to minimize the light from the surrounding nebula we used a $2\overset{\prime\prime}{.}5$ radius aperture. The background is taken between radii $10''$ and $12\overset{\prime\prime}{.}5$. The typical seeing during our observations vary between $1\overset{\prime\prime}{.}5$ and $2''$. The typical instrumental errors from CCD photometry are in the range $0\overset{\mathrm{m}}{.}01$- $0\overset{\mathrm{m}}{.}02$ for I and R, $0\overset{\mathrm{m}}{.}03$-$0\overset{\mathrm{m}}{.}05$ for V and $0\overset{\mathrm{m}}{.}05$-$0\overset{\mathrm{m}}{.}09$ for B filter. Aperture photometry of the digitized plates from POSS-I, POSS-II and Quick-V sky surveys was performed with the same parameters as for the CCD observations. The $BVRI$ comparison sequence reported in the present paper was used as a reference. The results of estimating magnitudes of the Palomar photographic plates are summarized in Table 4. The light curves of Parsamian 21 from all observations are plotted on Fig. 2. The photometric data published by Parsamian & Petrosian (1978) and Neckel & Staude (1984) are not consistent with our observations due to the different parameters of measurements (aperture radius and background position).

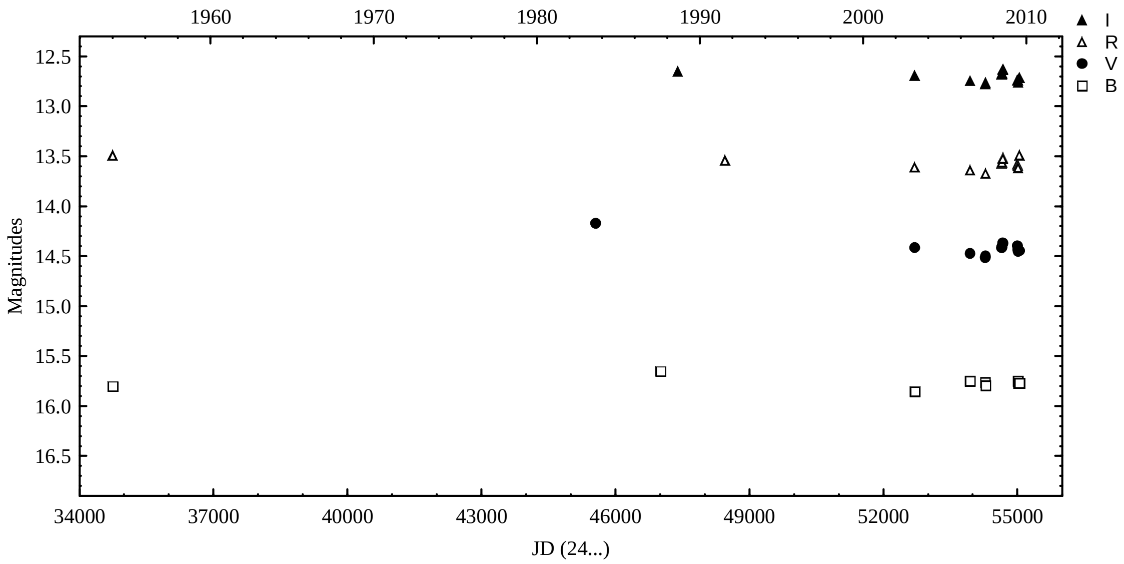

Figure 2. B/pg, V, R and I light curves of Parsamian 21.

Our CCD photometric observations of Parsamian 21 in the period 2003 - 2009 show that the brightness of the star is almost steady. We observed only low amplitude fluctuations of about $0\overset{m}{.}07$ (I) around the middle values. Comparing our CCD photometric observations with the data from Palomar plates showed no significant change in the brightness of the star for a very long period (57 years). Due to the small number of objects known as FUors their classification is very difficult. The shape of observed light curves of FUors may vary considerably from object to object. The results from our study suggest that the photometric behaviour of Parsamian 21 appears different from the well studied FUors (FU Ori, V1515 Cyg and V1057 Cyg). Another object with a similar photometric behaviour is the classical FUor star V1735 Cyg (Peneva et al., 2009). We conclude that Parsamian 21 is probably a member of the group of long-lived FUors and that the time-scale of the FUor phenomenon in some cases is much longer than that predicted in

Table 2. $VIcRcB$ photometric data for the comparison sequence

Star	R.A.(2000)	DEC.(2000)	V	σ_V	Ic	σ_I	Rc	σ_R	B	σ_B
A	19:28:51.92	09:40:45.3	14.418	0.020	13.210	0.023	13.838	0.027	15.411	0.047
B	19:28:57.51	09:41:15.3	14.474	0.028	12.569	0.026	13.500	0.037	16.229	0.064
C	19:28:59.17	09:36:00.8	14.969	0.039	12.422	0.040	13.676	0.044	17.160	0.021
D	19:29:01.43	09:37:26.4	15.138	0.015	14.071	0.016	14.606	0.025	16.049	0.035
E	19:29:08.80	09:38:37.7	15.402	0.043	12.514	0.043	14.008	0.045	17.730	0.044
F	19:28:52.86	09:38:51.3	15.450	0.036	13.172	0.035	14.270	0.042	17.449	0.053
G	19:28:55.53	09:40:02.8	16.325	0.028	14.826	0.040	15.596	0.033	17.546	0.040
H	19:28:57.29	09:39:25.5	16.536	0.035	14.560	0.044	15.519	0.045	18.239	0.080
I	19:28:57.77	09:39:10.3	16.698	0.051	15.158	0.033	15.920	0.035	18.044	0.175
J	19:28:54.35	09:38:37.2	16.934	0.041	14.821	0.023	15.843	0.049	18.700	0.207
K	19:29:01.73	09:40:26.8	16.943	0.028	14.680	0.039	15.778	0.042	18.911	0.114
L	19:29:04.29	09:37:07.1	17.429	0.026	15.300	0.043	16.366	0.045	19.247	0.074
M	19:29:05.72	09:37:08.1	17.560	0.056	15.386	0.037	16.461	0.048	19.472	0.300
N	19:29:02.01	09:40:44.9	17.746	0.042	16.270	0.062	17.045	0.055	18.891	0.094
O	19:29:04.25	09:40:01.5	17.937	0.063	16.535	0.058	17.157	0.073	19.346	0.149
P	19:29:03.50	09:40:15.6	18.311	0.038	16.225	0.099	17.246	0.039	20.069	0.217

previous studies.

Table 3. CCD photometric observations of Parsamian 21

Date	J.D.(245...)	*Ic*	*Rc*	*V*	*B*	CCD	Tel.
2003 Feb 27	2698.614	12.69	13.61	14.41	15.85	Photometrics	2m RCC
2006 Jul 21	3938.353	12.74	13.64	14.47	15.75	Photometrics	2m RCC
2007 Jun 26	4278.322	12.78	–	14.51	15.76	Photometrics	1.3m RC
2007 Jul 03	4285.313	12.76	13.67	14.50	15.79	Photometrics	1.3m RC
2008 Jun 28	4646.310	12.68	13.57	14.42	–	ANDOR	1.3m RC
2008 Jul 05	4653.313	12.68	13.56	14.40	–	ANDOR	1.3m RC
2008 Jul 06	4654.325	12.67	13.56	14.41	–	ANDOR	1.3m RC
2008 Jul 24	4672.316	12.63	13.51	14.37	–	ANDOR	1.3m RC
2008 Jul 25	4673.310	12.63	13.52	14.37	–	ANDOR	1.3m RC
2009 Jun 14	4997.515	12.74	13.58	14.40	–	ANDOR	1.3m RC
2009 Jun 26	5009.503	12.74	13.59	14.43	15.75	ANDOR	1.3m RC
2009 Jul 01	5014.502	12.76	13.62	14.45	15.77	ANDOR	1.3m RC
2009 Jul 31	5044.309	12.71	13.49	14.45	15.77	ANDOR	1.3m RC

Table 4. Photographic observations of Parsamian 21 from the Palomar Schmidt plates

Plate No.	Band	Date	J.D. (24...)	Magnitude
506E	R	1952 May 25	34742.016	13.49±0.09
506O	pg	1952 May 25	34742.032	15.80±0.10
573V	V	1983 Aug 11	45557.972	14.17±0.09
1333	B	1987 Jul 30	47006.938	15.65±0.10
3991	I	1988 Aug 19	47393.032	12.65±0.08
4712	R	1991 Jul 17	48455.032	13.53±0.08

Acknowledgements: This work was partly supported by grants DO 02-85, DO 02-273 and DO 02-362 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. The Digitized Sky Survey was produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. The images of these surveys are based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope. The plates were processed into the present compressed digital form with the permission of these institutions. This research has made use of NASA's Astrophysics Data System.

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