Photometric study of the FUor star V 1735 Cyg (Elias 1-12)

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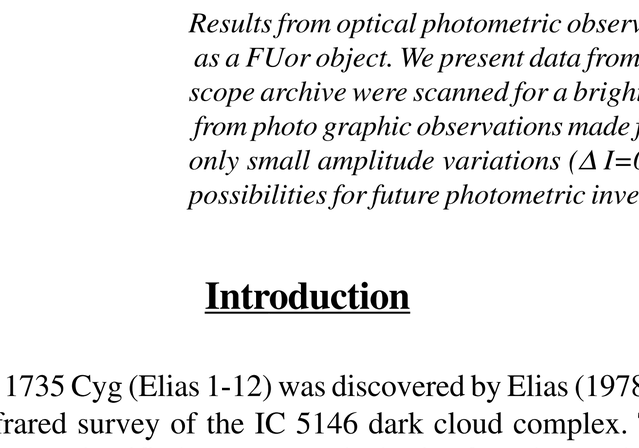
Results from optical photometric observations of the PMS star V 1735 Cyg are reported. On the basis of observed outburst and spectral properties, V 1735 Cyg was classified as a FUor object. We present data from IRVB CCD photometric observations of the star collected from March 2003 to January 2009. Plates from the Rozhen Schmidt telescope archive were scanned for a brightness estimation of the star. A sequence of sixteen comparison stars in the field of V 1735 Cyg was calibrated in IRVB bands. The data from photo graphic observations made from 1986 to 1992 show a strong light variability ($\Delta V = 1^m.2$). In contrast, the recent photometric data obtained from 2003 to 2009 show only small amplitude variations ($\Delta I = 0^m.3$). The analysis of existing photometric data shows a very slow decrease in star brightness – $1^m.8$ (R) for 44 years period. The possibilities for future photometric investigations of V 1735 Cyg using the photographic plate archives is discussed briefly.

Introduction

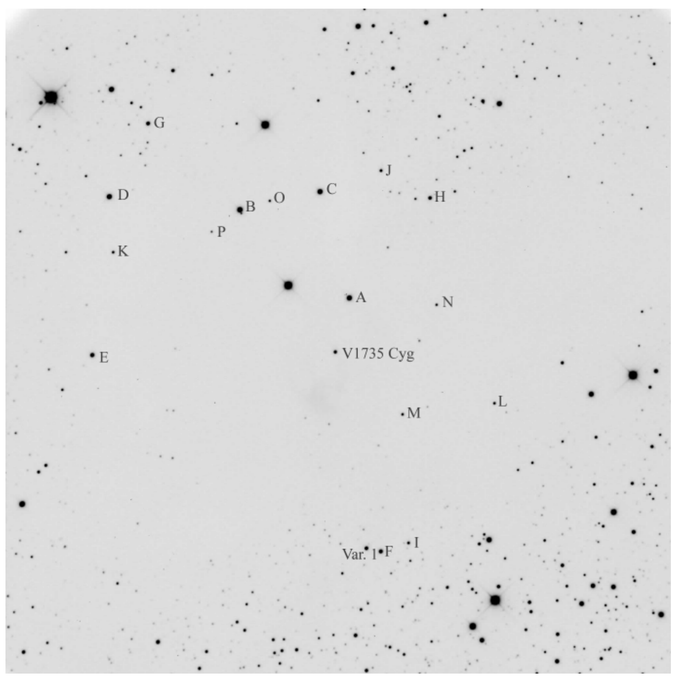
V 1735 Cyg (Elias 1-12) was discovered by Elias (1978) in an infrared survey of the IC 5146 dark cloud complex. The object was classified as FUor on the basis of an observed outburst, spectroscopic properties (Bastian and Mundt 1985) and association with a molecular outflow (Levreault 1983). The star appears to have brightened by 5 mag some time between 1957 and 1965. Subsequently, only few optical photometric estimations of V 1735 Cyg were published (Levreault 1988 and Goodrich 1987) and the light curve around and after the outburst is still undetermined. Abraham et al. (2004) documented a flux decrease of 40% for a 30 years period in the infrared K-band similar to other classical FUor stars. On the basis of X-ray detection Skinner et al. (2009) concluded that the central object in V 1735 Cyg is a high-luminosity and respectively high-mass ($M \geq 1.7\ M_{\odot}$) single T Tauri star.



The 2-m RCC telescope of NAO Rozhen

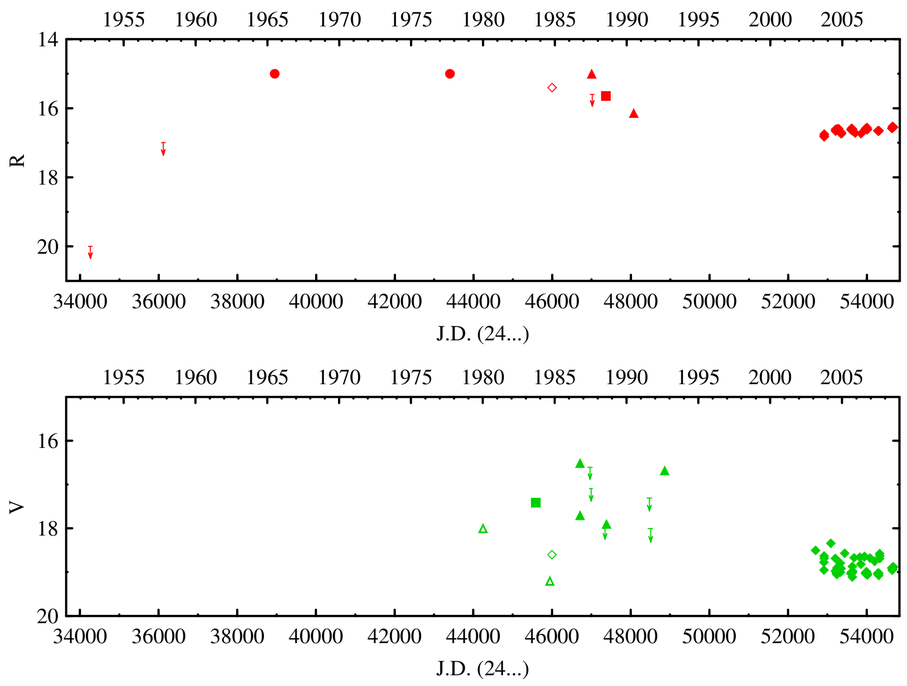
Observations

Our photometric CCD data were obtained in two observatories with three telescopes: the 2-m RCC and the 50/70/172-cm Schmidt telescopes of the National Astronomical Observatory Rozhen (Bulgaria) and the 1.3-m Ritchey-Cretien telescope of the Skinakas Observatory of the Institute of Astronomy, University of Crete (Greece). In order to facilitate transformation from instrumental measurement to the standard Johnson-Cousins system sixteen stars in the field of V 1735 Cyg were calibrated in *IRVB* bands.

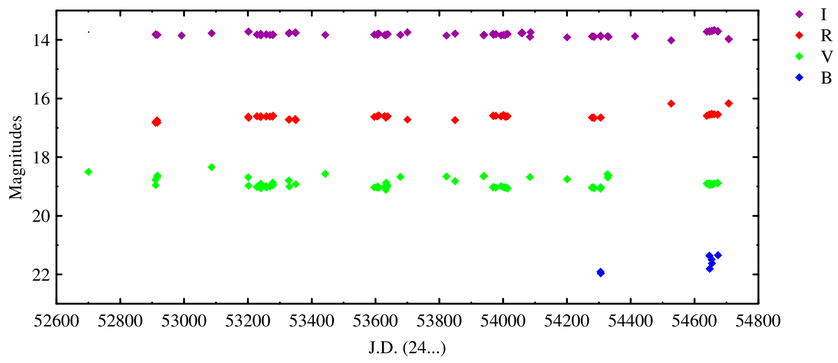


A finding chart for the IRVB comparison sequence around V 1735 Cyg. The comparison stars are labeled from A to P in order of their V magnitudes.

The plate archive of the 50/70-cm Schmidt telescope of Rozhen Observatory contains 82 photographic plates centered on IC 5146. The plates were obtained in the period 1984 – 1994 and most of them are blue plates (ORWO ZU21 emulsion with B filter). The visual inspection of these plates does not indicate the presence of V 1735 Cyg (the typical plate limits are $17^m.5 – 18^m.0$). The plates obtained on Kodak IIa-D emulsions with V filter and on Kodak 103a-F and 103a-E emulsions with R filter are scanned with Epson Expression 1640 XL scanner, 1600 dpi resolution, corresponding to 16 x 16 μm pixel size.



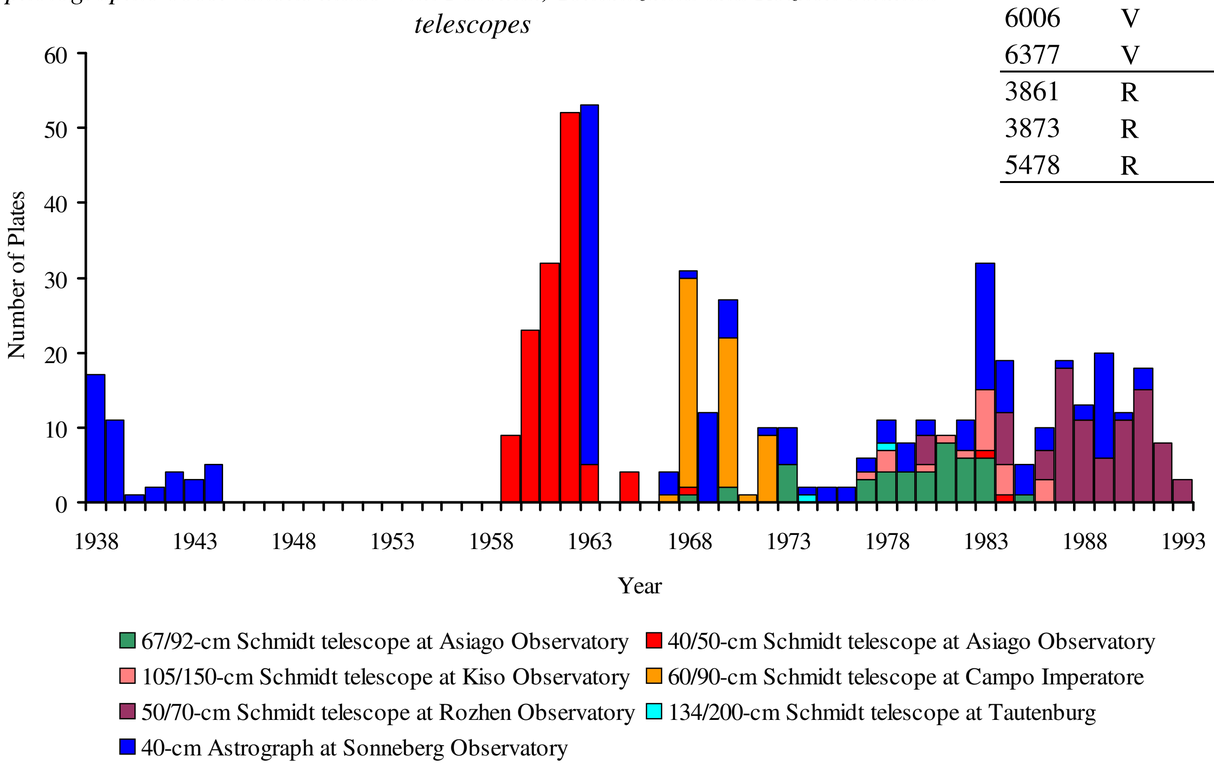
V and R light curves of V 1735 Cyg in the period 1952 – 2009. The filled triangles denote photographic data from the Rozhen Schmidt telescope, the filled diamonds: our CCD observations, the filled squares: photographic data from the Palomar Schmidt telescope, the filled circles: the data from Elias (1978), the open triangles: magnitudes published by Levreault (1988), the open diamonds: magnitudes published by Goodrich (1987). The arrows mark the upper limits from photographic observations made with Palomar, Tonantzintla and Rozhen Schmidt telescopes



IRVB light curves of V 1735 Cyg in the period Mar. 2003 – Jan. 2009

Photometric data from the photographic observations of V 1735 Cyg with the Schmidt telescope of Rozhen Observatory

Plate No.	Bandpass	Date	JD (244…)	Magnitude
3761	V	1986 Oct. 08	6712.316	16.5±0.1
3762	V	1986 Oct. 08	6712.351	17.7±0.2
3829	V	1987 Jun. 27	6973.500	>16.6
3836	V	1987 Jun. 29	6976.444	>16.6
3864	V	1987 Jul. 25	7002.361	>17.1
4462	V	1988 Jul. 20	7362.503	>18.0
4486	V	1988 Aug. 10	7384.471	17.9±0.3
5947	V	1991 Aug. 10	8479.352	>17.3
6006	V	1991 Sep. 14	8514.310	>18.0
6377	V	1992 Sep. 27	8862.303	16.7±0.1
3861	R	1987 Jul. 25	7001.514	>15.6
3873	R	1987 Jul. 26	7003.430	15.0±0.2
5478	R	1990 Jun. 30	8072.502	16.1±0.1



Number of plates containing the field of V 1735 Cyg versus year of observations for seven telescopes

Results and Discussion

Using the collected data from photographic and CCD observations we try to construct the historical light curve of V 1735 Cyg and to study the photometric behavior of the star around the optical outburst and in the time of set in brightness. The analysis of the available photometric data for V 1735 Cyg leads to some important conclusions. The time of rise in brightness and the star magnitude in the maximum light are still under discussion. The data from photographic observations made with the 50/70-cm Schmidt telescope from 1986 to 1992 show a strong light variability ($\Delta V = 1^m.2$). Taking into account the magnitudes from Levreault (1988) and Goodrich (1987) the registered amplitude of V 1735 Cyg in the period 1980 – 1992 is $\Delta V = 2^m.7$. In contrast, the recent photometric data obtained from March 2003 to January 2009 show only small amplitude variations ($\Delta I = 0^m.3$). Such change of the photometric activity during the period of set in brightness was not observed for the other FUor objects. The analysis of existing photometric data shows a very slow decrease in star brightness – $1^m.8$ (R) for 44 years period.

The shape of observed light curves of FUors may vary considerably from object to object. While the time of rise for FU Ori and V 1057 Cyg is in the order of 1 year, for V 1515 Cyg it is considerably longer – ~ 25 years. Respectively, the rate of decrease in brightness is quite different for each of them. While the brightness of V 1057 Cyg reaches the pre-outburst level after ~ 30 years, the decrease in brightness of FU Ori and V 1515 Cyg goes much slower. The available photometric data for V 1735 Cyg are not enough at present to determine the time of rise to the maximum brightness, but the rate of decrease in brightness is definitely similar to the observed in the cases of FU Ori and V 1515 Cyg. Our data show that V 1735 Cyg must be added to the group of long-lived FUors and that the time-scale of the FUor phenomenon must be much longer than the assumed in previous studies (Herbig 1977, Reipurth 1990).

The results from photographic observations with the Rozhen Schmidt telescope, show the importance of archival plate collections for long-term photometric studies of PMS stars. Our search in the Wide-Field Plate Database (WFPDB) (Tsvetkov et al. 1997), limited to clear telescope aperture >40 cm show the possibility to find archival photographic observations of V 1735 Cyg in some telescope plate collections.

We find the photometric studies of FUor and FUor-like objects as very important for their exact classification. The problems with duration and possible recurrence of FUor stage can by solved by collecting photometric data from the photographic plate archives and with photometric monitoring in the present time. Another disputed point that can be solved by photometric monitoring of star forming regions is the percentage of PMS stars passing through a FUor outburst.

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