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PHOTOELECTRIC OBSERVATIONS OF FLARE STAR EV Lac IN 1984

Within the framework of the program of investigation of flare stars in the solar neighbourhood and stellar aggregates patrol observations of the flare star EV Lac have been carried out in the Rozhen National Astronomical Observatory in the autumn of 1984 (Tsvetkov et al., 1986). These observations were made with the 60-cm Cassegrain telescope, using an EF_1 one-channel electrophotometer (Panov et al., 1981). The accuracy in the U-band was $\sigma \leq 0.09$, integration time 1s. For the patrol observations of EV Lac together with its optical companion (an A-type star of constant brighness; V=12.00, B=12.74 and U=12.95 according to Andrews and Chugainov, 1969) a diaphragm of diameter 1.5 mm(41.25 arcsec) was used. This has to be taken into consideration when using the data listed in the table for recorded flares where no corrections have been made for stellar companions.

For $15^h42^m43^s$ effective observation time 17 flare events were detected some of which forming separate groups of flares.

Table I lists the total effective observation time in each individual night, and the respective number of detected flare events during the patrol observations of EV Lac.

Table II lists data on these flare events, viz. date and the moment of maximum brightness in universal time, duration before and after this maximum (t_b and t_a, respectively) and total duration of the flare ; value of the relation $(I_f+I_o)/I_o$ for the maximum of the flare, where I_o is the intensity deflection less sky background of the quiet star and I_F is the total intensity deflection less sky background of the star plus flare, the integrated intensity of the flare over its total duration, including pre-flares, if present, $P= \int(I_f-I_o)/I_o\, dt$, the increase of the apparent magnitude of the star at flare maximum $\Delta m_u=2.5\log (I_f/I_o)$, where u is the uv magnitude of the star in the instrumental system, the standard deviation of random noise fluctuation $\sigma(mag)= 2.5\log (I_o+\sigma)/I_o$ during the quiet-state phase immediately preceding the beginning of the flare, and the air mass at flare maximum.

Fig.1 shows the light curves of spike flares observed in the u band.

During the patrol observations a number of estimations of the brightness

of EV Lac were made using standards C_1 and C_2 according to Pettersen (1980) and its brightness was found to be comparatively constant.

Table I

Total monitoring time

Date	T_{eff}	Observed flares
18/19 Oct. 1984	$3^h\ 23^m\ 12^s$	8
19/20 Oct. 1984	5 35 07	4
20/21 Oct. 1984	1 40 01	2
21/22 Oct. 1984	1 45 26	1
23/24 Oct. 1984	1 04 58	1
10/11 Nov. 1984	2 13 59	1
Total: on six nights	$15^h\ 42^m\ 43^s$	17

Table II

Characteristics of the flares observed

	Date 1984	U T_{max}	t_b min	t_a min	D_{min}	$\frac{I_f-I_o}{I_o}$	P	Δm_u mag	σm_u mag	X
1	18 Oct.	$20^h33^m43^s$	0.120	3.280	3.400	0.729	0.310	0.59	0.05	1.04
2	-"-	21 02 57	0.533	22.383	22.916	3.503	6.236	1.63	0.05	1.06
3	-"-	22 17 49	6.183	11.517	17.700	0.860	1.573	0.67	0.04	1.19
	A	22 11 46	0.133	>2.867	>3.000	0.223	>0.163	0.22	0.04	1.18
	B	22 14 51	0.217	>0.800	>1.017	0.532	0.240	0.46	0.04	1.18
	C	22 15 40	0.017	>0.650	>0.667	0.361	0.108	0.33	0.04	1.18
	D	22 16 23	0.067	>0.933	>1.000	0.288	0.134	0.27	0.04	1.18
	E	22 17 49	0.500	11.517	12.017	0.860	0.928	0.67	0.05	1.19
4	-"-	22 31 19	0.008	0.008	0.017	1.465	0.024	0.71	0.05	1.22
5	-"-	22 31 26	0.008	0.008	0.017	1.013	0.017	0.41	0.05	1.22
6	-"-	22 31 33	0.008	0.008	0.017	4.654	0.078	1.77	0.05	1.22
7	-"-	22 31 36	0.008	0.008	0.017	1.006	0.017	0.41	0.05	1.22
8	19 Oct.	00 44 36	-	9.067	>9.067	>0.458	>0.170	0.41	0.07	1.85
9	-"-	19 13 43	0.380	1.720	2.100	0.192	0.105	0.19	0.05	1.00
10	-"-	20 15 58	0.008	0.025	0.033	1.951	0.065	1.17	0.06	1.02
11	-"-	21 01 23	0.100	3.950	4.050	0.283	0.178	0.27	0.05	1.06
12	-"-	21 37 28	2.75	1.20	3.95	0.230	0.288	0.23	0.05	1.12
13	20 Oct.	20 19 54	0.833	2.117	2.95	0.241	0.197	0.23	0.04	1.03
14	-"-	21 00 32	0.917	1.55	2.467	0.368	0.449	0.34	0.05	1.07
15	21 Oct.	18 59 10	0.633	2.333	2.966	0.250	0.188	0.24	0.05	1.00
16	23 Oct.	20 56 32	0.366	1.716	2.083	0.420	0.380	0.38	0.05	1.08
17	10 Nov.	18 34 37	0.150	1.817	1.967	1.022	2.589	0.77	0.09	1.01

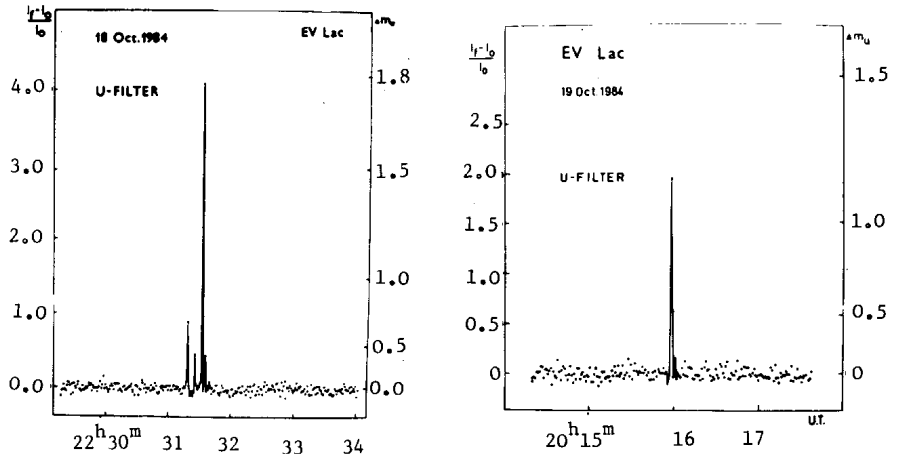

Figure 1

The following mean values of the brightness of EV Lac in the instrumental ubv system were established:

$\bar{v}$=10.04±0.04 ; $\bar{b}$=11.42±0.05; $\bar{u}$=12.24±0.05

Using the following equations our instrumental system was converted into the international UBV system as follows:

$\Delta V = (0.105\Delta(B-V)$; $\Delta(B-V) = 1.118\Delta(b-v)$; $\Delta(U-B) = 0.800\Delta(u-b)$

Figure 1 shows the light curves of spike flares observed in the u band.

Before discussing the physical conditions causing flare events of such a short duration and relatively high amplitude up to $\Delta m_u = 2^m.49$*(No. 6) it is necessary to make sure that there are neither instrumental errors nor other influences.

Current printed records of spike flares of EV Lac and other flare stars are of very great importance for the elucidation of their nature. Over the last decade a number of astronomers engaged in patrol observations of flare stars, were faced with similar phenomena still insufficiently corroborated. There are several factors accounting for the difficulties; duration of the flares is close to the integration time of the device used for the patrol observations ; the phenomenon occurs mainly in the U-band, and with simultaneous observations the amplitudes in the B-band are generally by approximately 1 stellar magnitude smaller ; possible interference that may cause spikes in the device.

*If EV Lac's companion is taken into consideration in estimating the amplitude of flare No. 6, its influence would increase the value by $\Delta m_u = 0^m.723$.

A most reliable evidence of the existence of such flares would be provided by simultaneous observations of high time resolution, varying from 0.1s to 1s, in the ultraviolet band simultaneously on two telescopes.

In this sense the publication of the present results may be regarded as launching a call to put forward such a program. Another reason is that as early as in 1972, Moffett gave valid grounds for the project of making high time resolution patrol observations. Parallelly an increasing number of authors obtain results suggestive of similar spike flares - in the optical spectral region of flare stars UV Cet, EV Lac and AD Leo (Cristaldi and Rodono, 1970,1973 ; Gershberg and Petrov, 1985 ; Zalinian and Tovmassian, 1986 ; Ichimura and Shimizu, 1986).

Beskin et al. (1985) could not detect such flare events on the 6m telescope of the Special Astrophysical Observatory, when a MANIA device was used to detect small-scale time changes in flare events in some UV Ceti type stars. On the other hand, Lang et al. (1983) detected similar spike flares of 0.1s duration in the radiorange during a flare event in AD Leo.

In view of the contentions made regarding the physical conditions in the atmosphere of flare stars at the time of their activity (Ambartsumian, 1954; Ambartsumian, Mirzoyan, 1982) it is of primary importance to prove the existence of rapid flare activity of UV Ceti stars, of small-scale time structure of the flare, and the existence of spike flares, as well.

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