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PHOTOELECTRIC OBSERVATIONS OF THE FLARE STAR EV Lac IN 1976

Continuous photoelectric monitoring of the flare star EV Lac has been carried out at the Stephanion Observatory ( $\lambda = -22^{\circ}49'44''$ ,  $\varphi = +37^{\circ}45'15''$ ) during the year 1976 using the 30-inch Cassegrain reflector of the Department of Geodetic Astronomy, University of Thessaloniki. Observations have been made with a Johnson dual channel photoelectric photometer in the B color of the international UBV System. The telescope, the photometer and the observational procedure have been described elsewhere (Mavridis et al., 1982). Here we mention only that the transformation of our instrumental ubv system to the international UBV system is given by the following equations:

$$\begin{aligned}V &= v_o + 0.042(b-v)_o + 2.278 \\B-V &= 0.706 + 1.043(b-v)_o, \\U-B &= -2.550 + 1.490(u-b)_o.\end{aligned}$$

The monitoring intervals in UT as well as the total monitoring time for each night are given in Table I. Any interruption of more than one minute has been noted.

During the 198.37 hours of monitoring time 17 flares were observed the characteristics of which are given in Table II. For each flare following characteristics (Andrews et al., 1969) are given: a) the date and universal time of flare maximum, b) the duration before and after the maximum ( $t_b$  and  $t_a$ , respectively), as well as the total duration of the flare, c) the value of the ratio  $(I_F - I_o)/I_o$  corresponding to flare maximum, 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

Table I  
Monitoring Intervals in 1976

Date 1976	Monitoring Intervals (U.T.)	Total Monitoring Time
July		
21-22	23 <sup>h</sup> 52 <sup>m</sup> -00 <sup>h</sup> 37 <sup>m</sup> , 00 <sup>h</sup> 39 <sup>m</sup> -01 <sup>h</sup> 11 <sup>m</sup> .	01 <sup>h</sup> 17 <sup>m</sup>
22-23	22 23 -23 01 , 23 04 -23 45 , 23 48 -00 31, 00 34 -01 05.	02 33
23-24	22 24 -23 13 , 23 16 -00 00 , 00 03 -01 07.	02 37
August		
5-6	23 00 -23 29 , 23 32 -00 02 , 00 05 -00 35, 01 16 -01 36.	01 49
7-8	19 57 -20 26 , 20 28 -21 00 , 21 02 -21 31, 21 43 -22 13, 22 15 -22 48 , 22 50 -23 23 , 23 34 -23 51, 23 53 -00 36, 00 39 -01 06 , 01 08 -01 43 .	05 08
8-9	20 02 -20 27 , 20 29 -20 58 , 21 00 -21 31, 21 49 -22 19, 22 22 -22 49 , 22 51 -23 25 , 23 35 -00 01, 00 55 -01 40.	04 07
12-13	20 03 -20 35 , 20 38 -21 06 , 21 09 -21 35, 21 45 -22 14, 22 16 -22 45 , 22 47 -23 14 , 23 36 -23 54, 23 58 -00 26, 00 29 -01 00 , 01 14 -01 49 .	04 43
14-15	20 16 -20 44 , 20 47 -21 16 , 21 18 -21 46, 21 58 -22 28, 22 31 -23 01 , 23 26 -00 00 , 00 11 -00 41, 00 44 -01 13, 01 16 -01 41 .	04 23
16-17	20 02 -20 32 , 20 36 -21 03 , 21 05 -21 37, 21 40 -22 10, 22 19 -22 46 , 22 49 -23 20 , 23 24 -23 44, 23 55 -00 31, 00 33 -01 12 , 01 14 -01 45 .	05 03
17-18	21 28 -21 56 , 21 59 -22 33 , 22 36 -23 01, 23 11 -23 39, 23 42 -00 07 , 00 09 -00 40 , 00 53 -01 24, 01 26 -02 00.	03 56
18-19	21 19 -21 50 , 21 53 -22 23 , 22 25 -23 13, 00 56 -01 36, 01 38 -02 02 .	02 53
19-20	19 47 -20 20 , 20 23 -20 56 , 20 59 -21 37, 21 52 -22 28, 22 30 -23 04 , 23 06 -23 33 , 23 51 -00 42, 00 43 -01 22, 01 24 -02 11 .	05 38
20-21	19 42 -19 59 , 20 28 -20 54 , 21 01 -21 20, 21 54 -22 04, 22 06 -22 34 , 22 36 -23 00 , 23 11 -23 45, 23 48 -00 05, 00 18 -00 29 , 00 32 -00 54 , 01 17 -02 13.	04 24
21-22	20 36 -21 04 , 21 06 -21 29 , 21 31 -21 38, 21 46 -22 12, 22 14 -22 32 , 22 44 -22 57 , 23 00 -23 14, 23 17 -23 48, 23 51 -00 25 , 00 38 -00 41 , 00 44 -01 31, 01 33 -02 11.	04 42
22-23	23 04 -23 40 , 23 42 -00 15 , 00 18 -00 59, 01 08 -01 44, 01 45 -02 24 .	03 05
25-26	21 35 -21 58 , 22 01 -22 36 , 22 39 -23 14, 23 27 -23 58, 00 01 -00 31 , 00 33 -01 01 .	03 02
26-27	20 33 -21 02 , 21 04 -21 32 , 21 33 -22 00, 22 10 -22 43, 22 46 -23 24 , 23 26 -00 03 , 00 13 -00 57, 01 01 -01 33, 01 35 -02 05 .	04 58
27-28	20 48 -21 27 , 21 29 -21 59 , 22 02 -22 33, 23 13 -23 49, 23 52 -00 32 , 00 34 -01 15 , 01 31 -02 31.	04 37
28-29	20 34 -21 10 , 21 11 -21 40 , 21 43 -22 18, 22 30 -23 06, 23 09 -23 36 , 23 38 -00 09 , 00 22 -00 59, 01 02 -01 46, 01 49 -02 20 .	05 06
29-30	19 42 -20 16 , 20 18 -20 47 , 20 50 -21 18, 21 30 -22 00, 22 02 -22 34 , 22 36 -23 05 , 23 18 -00 00, 00 02 -00 43, 00 46 -01 30 , 01 39 -02 28 .	05 58
30-31	20 00 -20 31 , 20 34 -21 08 , 21 11 -21 37, 21 48 -22 23, 22 25 -22 53 , 23 40 -00 14 , 00 16 -00 55, 00 58 -01 37, 01 46 -02 31 .	05 11
31	22 07 -22 39 , 22 41 -23 23 , 23 25 -00 00.	01 49

Table I (Continued)

September		00 <sup>h</sup> 10 <sup>m</sup> -00 <sup>h</sup> 50 <sup>m</sup> , 00 <sup>h</sup> 53 <sup>m</sup> -01 <sup>h</sup> 03 <sup>m</sup> , 01 <sup>h</sup> 06 <sup>m</sup> -01 <sup>h</sup> 59 <sup>m</sup> .				01 <sup>h</sup> 43 <sup>m</sup>
1						
1-2	19 55 -20 25 , 23 10 -23 28 , 01 12 -01 58 .	20 35 -21 18 , 23 41 -00 01 ,	21 21 -21 54 , 00 04 -00 32 ,	21 57 -22 27 , 00 34 -01 01 ,		
2-3	20 39 -21 12 , 23 46 -00 04 ,	21 15 -21 51 , 00 20 -00 59 ,	21 54 -22 27 , 01 10 -01 59 .	23 04 -23 43 ,	04 35	04 07
3-4	19 57 -20 35 , 23 39 -00 13 ,	20 39 -21 19 , 00 16 -00 51 ,	21 21 -22 10 , 01 02 -01 28 ,	22 52 -23 35 , 01 31 -01 57 .	04 51	
4-5	20 16 -21 02 , 23 36 -00 02 ,	21 05 -21 42 , 00 04 -00 44 ,	21 46 -22 22 , 00 55 -01 26 ,	22 59 -23 29 , 01 29 -02 02 .	04 39	
5-6	19 55 -20 43 , 22 38 -23 14 , 01 20 -01 59 .	20 47 -21 14 , 23 16 -23 54 ,	21 17 -21 48 , 00 10 -00 42 ,	21 59 -22 36 , 00 44 -01 17 ,	05 21	
11-12	19 36 -20 12 , 23 04 -23 38 , 01 29 -02 01 .	20 13 -20 56 , 23 40 -00 03 ,	20 58 -21 46 , 00 14 -01 03 ,	22 26 -23 02 , 01 05 -01 27 ,	05 23	
12-13	20 16 -20 49 , 23 55 -00 48 ,	20 51 -21 50 , 00 58 -01 29 ,	22 32 -23 18 , 01 31 -02 00 .	23 23 -23 53 ,	04 41	
13-14	20 00 -20 35 , 23 13 -23 37 , 01 33 -01 57 .	20 39 -21 14 , 23 44 -00 26 ,	21 15 -21 47 , 00 36 -01 01 ,	22 28 -23 10 , 01 03 -01 30 ,	04 46	
14-15	19 35 -20 16 , 22 52 -23 38 ,	20 27 -20 41 , 23 50 -00 38 ,	20 49 -21 41 , 00 48 -01 23 ,	22 16 -22 49 , 01 25 -02 00 .	05 04	
15-16	19 41 -20 19 , 23 11 -23 40 , 01 31 -02 01 .	20 22 -20 59 , 23 43 -00 03 ,	21 01 -21 38 , 00 12 -00 52 ,	22 14 -22 56 , 00 55 -01 28 ,	05 06	
16-17	19 24 -20 03 , 22 54 -23 28 , 01 24 -01 58 .	20 05 -20 55 , 23 31 -23 58 ,	20 59 -21 31 , 00 00 -00 39 ,	22 06 -22 37 , 00 50 -01 21 ,	05 17	
17	19 36 -20 03 ,	20 07 -21 28 ,	22 02 -22 41 ,	22 45 -23 00 .	02 42	
18-19	20 26 -21 29 , 23 53 -00 36 ,	22 01 -22 37 , 00 40 -01 14 ,	22 38 -23 05 , 01 16 -02 02 .	23 12 -23 43 ,	04 40	
19-20	20 06 -20 37 , 22 49 -23 18 ,	20 39 -21 14 , 23 20 -23 43 ,	21 46 -22 05 , 23 54 -00 24 ,	22 15 -22 46 , 00 27 -00 56 .	03 47	
25-26	20 09 -21 07 , 23 31 -00 05 ,	21 43 -22 10 , 00 08 -00 31 ,	22 13 -22 46 , 00 34 -00 58 ,	22 48 -23 19 , 01 13 -01 56 .	04 13	
26-27	19 59 -20 46 , 23 02 -23 35 ,	21 21 -21 49 , 23 38 -00 09 ,	21 51 -22 22 , 00 18 -01 00 .	22 25 -22 52 ,	03 59	
28-29	19 19 -20 02 , 22 20 -22 56 , 00 23 -00 50 ,	20 04 -20 36 , 23 06 -23 26 , 00 52 -01 14 ,	21 09 -21 45 , 23 37 -23 42 , 01 26 -02 13 .	21 47 -22 17 , 23 50 -00 21 ,	05 29	
29-30	19 36 -20 07 , 22 19 -22 57 , 00 55 -01 19 ,	20 09 -20 37 , 23 08 -23 37 , 01 24 -01 39 ,	21 10 -21 43 , 23 40 -00 10 , 01 49 -02 15 .	21 45 -22 15 , 00 20 -00 45 ,	05 08	
30	19 34 -20 01 , 22 25 -22 52 ,	20 04 -20 36 , 23 02 -23 33 ,	21 10 -21 47 , 23 47 -00 00 .	21 52 -22 22 ,	03 17	
October						
1	00 00 -00 32 ,	00 35 -01 03 ,	01 14 -01 57 .		01 43	
2-3	20 01 -20 27 , 22 38 -23 05 , 01 02 -02 02 .	20 29 -21 13 , 23 08 -23 33 ,	21 15 -21 53 , 23 44 -00 26 ,	22 01 -22 34 , 00 28 -00 52 ,	05 19	
3-4	19 22 -19 49 , 21 35 -22 09 , 00 11 -00 44 ,	19 51 -20 20 , 22 10 -22 40 , 00 58 -01 31 ,	20 22 -20 48 , 22 53 -23 27 , 01 33 -02 02 .	21 00 -21 33 , 23 39 -00 08 ,	05 37	

Table I (Continued)

October									
10	19 <sup>h</sup> 42 <sup>m</sup> -20 <sup>h</sup> 15 <sup>m</sup> , 20 <sup>h</sup> 17 <sup>m</sup> -20 <sup>h</sup> 50 <sup>m</sup> , 20 <sup>h</sup> 52 <sup>m</sup> -21 <sup>h</sup> 23 <sup>m</sup> , 21 <sup>h</sup> 34 <sup>m</sup> -22 <sup>h</sup> 03 <sup>m</sup> ,								
	20 05 -22 31 , 22 33 -23 01 .								03 <sup>h</sup> 00 <sup>m</sup>
11-12	19 25 -19 57 , 19 59 -20 30 , 20 32 -21 05 , 21 16 -21 49 ,								
	21 51 -22 23 , 22 25 -23 07 , 23 20 -23 25 , 23 28 -00 07 , ,								
	00 09 -00 38 , 00 50 -01 12 .								04 58
12-13	22 55 -23 28 , 23 31 -00 04 , 00 07 -00 52 , 01 05 -01 12 .								01 58
Total									198 <sup>h</sup> 22 <sup>m</sup> = 198 <sup>h</sup> .37

Table II

## Characteristics of the Flares Observed

Flare No.	Date 1976	U.T.	$t_b$	$t_a$	Duration	$I_f - I_0 / I_0$		P	$\Delta m$	$\sigma$	Air mass
						max	min				
1	23 July	22 <sup>h</sup> 24 <sup>m</sup> .54	0.33	0.62	0.95	0.22	0.04	0.22	0.06	1.02	
2	7 Aug.	23 38.04	0.78	6.20	6.98	0.68	1.30	0.56	0.09	1.01	
3	20	02 01.08	0.74	3.14	3.88	0.33	0.38	0.31	0.06	1.16	
4	27	01 40.20	0.96	2.12	3.08	0.18	0.11	0.18	0.06	1.18	
5	29	02 05.04	0.72	3.72	4.44	0.22	0.19	0.22	0.05	1.26	
6	31	02 08.22	0.84	8.28	9.12	0.61	0.79	0.52	0.07	1.30	
7a	1 Sept.	19 57.66	0.24	26.78	27.02	1.57	5.71	1.02	0.06	1.14	
7b	1					0.93		0.71			
8	3	01 31.68	0.30	0.56	0.86	0.17	0.03	0.17	0.05	1.23	
9	15	22 34.14	1.06	11.42	12.48	3.54	5.35	1.64	0.04	1.03	
10	15	23 43.92	0.48	9.46	9.94	2.38	3.58	1.32	0.07	1.10	
11	16	22 16.86	1.08	15.16	16.24	0.51	3.16	0.45	0.06	1.02	
12	19	21 50.82	0.12	1.48	1.60	0.37	0.06	0.34	0.06	1.01	
13	25	20 12.84	0.96	14.24	15.20	0.21	1.57	0.21	0.05	1.02	
14	28	23 12.18	0.54	0.86	1.40	0.19	0.05	0.19	0.05	1.14	
15	30	01 24.36	0.24	3.40	3.64	0.69	0.60	0.57	0.06	1.64	
16	3 Oct.	23 40.66	0.36	1.98	2.34	0.36	0.15	0.33	0.08	1.26	
17	11	20 40.20	0.36	2.42	2.78	0.48	0.25	0.43	0.08	1.02	

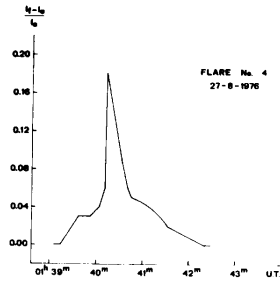
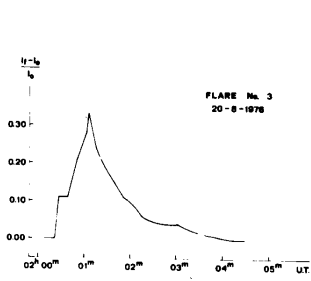
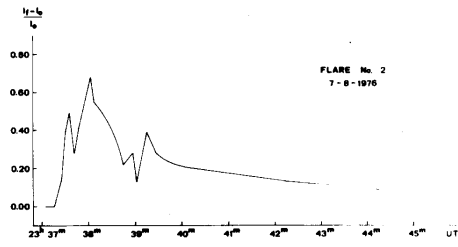
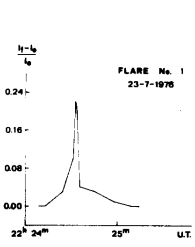
star plus flare, d) the integrated intensity of the flare over its total duration, including preflares, if present,

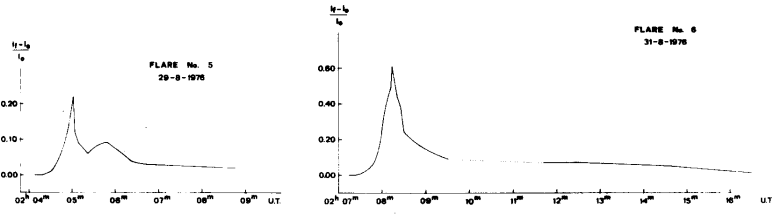
$$p = \int (I_f - I_0) / I_0 dt, \text{ e) the increase of the apparent magnitude of the star at flare maximum } \Delta m(b) = 2.5 \log(I_f / I_0), \text{ where } b \text{ is the}$$

blue magnitude of the star in the instrumental system, f) the standard deviation of random noise fluctuation

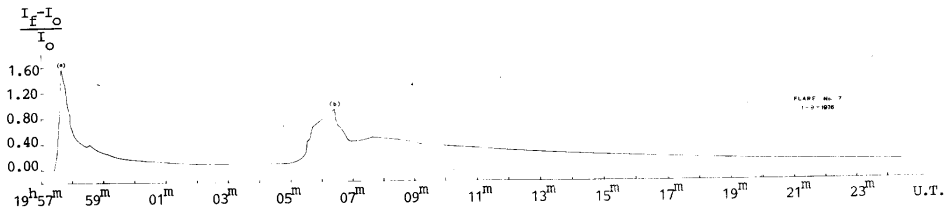
$\sigma(\text{mag}) = 2.5 \log(I_0 + \sigma) / I_0$  during the quiet - state phase immediately preceding the beginning of the flare and g) the air mass at flare maximum. The light curves of the observed flares in the

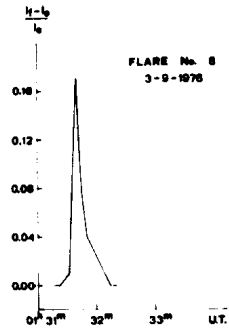
b color are shown in Figs. 1-17.

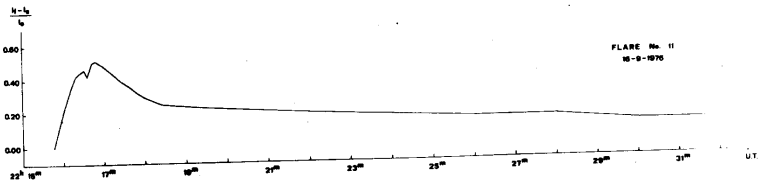
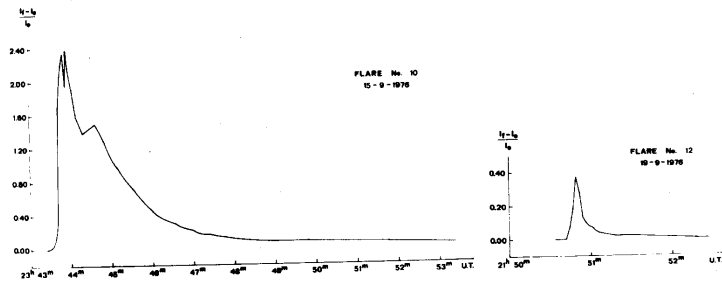




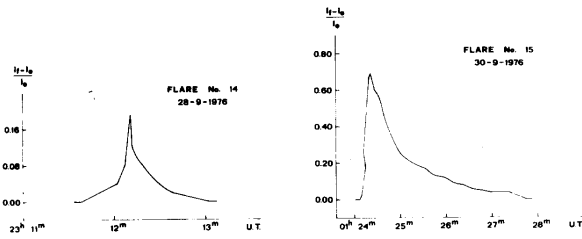
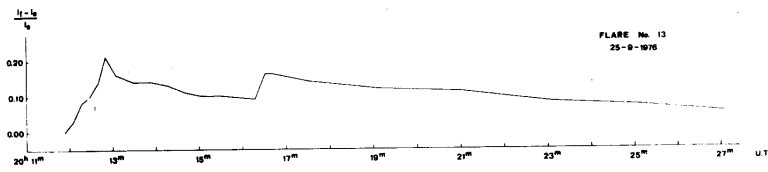
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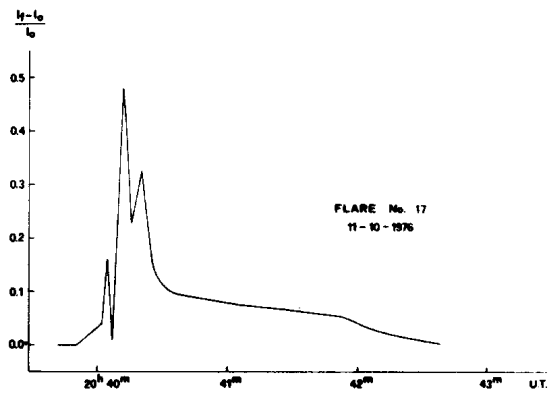
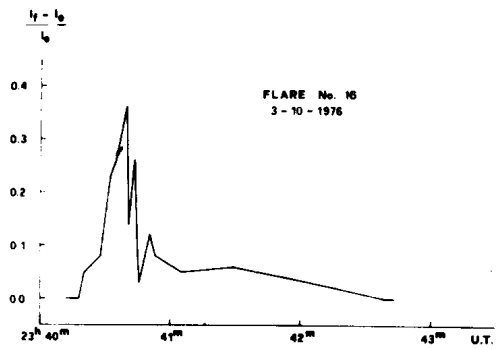












Figures 1-17

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