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STATISTICAL ANALYSIS OF FLARE STAR OBSERVATIONS

A large scale photoelectric monitoring program on five flare stars was carried out at the Stephanion Observatory, Greece during the period 1972-1976. The observations enable us to make some comments on these stars.

I. One of the main problems of flare star observations is how to separate the flare events from the noises caused by the equipments used and by the instabilities of the Earth's atmosphere. In order to minimize the thermoionic effects we used dry carbondioxide ice for cooling. The observations were made in the B band.

The fluctuation of the observations of the five flare stars has been measured at every certain interval of time ΔT to avoid random values. The name of the stars and the number of points measured are given in Table I for the years 1973 and 1974, separately. The total monitoring time was 124 hours.

Table I

No.	Name of the flare star	No. of measured points in 1973	No. of measured points in 1974
1	BY Dra	265	89
2	EV Lac	144	87
3	BD $+13^{o}2618$	46	---
4	BD $+55^{o}1823$	---	213
5	AD Leo	---	52

$\sigma(m)$ and η were calculated from the following formulae:

$$\sigma(m)=2.5 \log \frac{I_o + \sigma(I)}{I_o} , \quad \text{where} \quad \sigma(I)=\sqrt{\frac{(I_i - \bar{I})^2}{N - 1}} ,$$

I_i= measured intensity deflection (i=1,2,...,N)

$I = \frac{1}{N} \sum_{i=1}^{N} I_i$, I_o= intensity deflection of the flare star at quiescence less background, and

$\eta = \frac{\Delta m}{\sigma(m)}$, where $\Delta m = 2.5 \log \frac{I_f}{I_o}$, $I_f = I_o$ + noise deflection.

The distribution of η for each observed flare star for the years 1973 and 1974, respectively are shown in Figs. 1 and 2.

A careful and refined analysis of these figures gives the η values which correspond to more than 99% confidence that the flucuation is a flare event. The results are summarized in Table II.

Table II

No.	Name of the flare star	η with confidence more than 99%, in 1973	η with confidence more than 99%, in 1974
1	BY Dra	5.0 ± 0.05	5.0 ± 0.09
2	EV Lac	4.0 ± 0.06	4.0 ± 0.07
3	BD $+13^{\circ}2618$	6.0 ± 0.16	---
4	BD $+55^{\circ}1823$	---	4.0 ± 0.04
5	AD Leo	---	4.0 ± 0.10

The mean value of $\eta = 4.57 \pm 0.30$ i.e. $\eta \approx 5$, which is a suitable criterion for our photoelectric observations of flare event detection in the B - colour with a confidence more than 99%, i.e. if $\Delta m \geq 5\sigma(m)$, we can say with more than 99% confidence that the event is a flare.

II. Kunkel (1973) defined a flare duration parameter T_q where the subscript q denotes the fraction of peak light at which the measurement was taken (e.g. $T_{0.5}$ is the duration of a flare at half peak light, $T_{0.2}$ is the duration at 20% of peak light, etc.). He found an empirical formula between the luminosity of the flare star of dMe type and the flare duration observed in the U - band:

$$\langle \log T_{0.5} \rangle = -0.15\, M_V + 1.61 \pm 0.17$$

From our data for the flare star EV Lac which was observed from 1972 through 1976 and 75 flare events were detected in the B band, we were able to determine Kunkel's parameter T_q for q= 0.5, 0.2 and 0.1 (Table III). Omitting the very uncertain values of the events Nos 21,40,46,51 and 65 we obtain:

$$\langle \log T_{0.5} \rangle = -0.092 \pm 0.036$$
$$\langle \log T_{0.2} \rangle = +0.186 \pm 0.046$$
$$\langle \log T_{0.1} \rangle = +0.375 \pm 0.052$$

Table III

No. of flare events	$T_{0.5}$	$T_{0.2}$	$T_{0.1}$	No. of flare events	$T_{0.5}$	$T_{0.2}$	$T_{0.1}$
1	$1^{m}.46$	$3^{m}.50$	$4^{m}.15$	39	$2^{m}.32$	$9^{m}.85$	$12^{m}.60$
2	0.64	0.95	–	40	–	–	–
3	0.56	0.75	2.40	41	1.46	4.60	–
4	0.34	–	–	42	1.30	4.85	5.85
5	1.44	2.00	7.05	43	0.74	1.75	3.20
6	0.36	0.60	2.95	44	1.62	1.90	2.10
7	0.94	1.20	2.09	45	0.60	–	–
8	0.92	1.23	2.53	46	–	–	–
9	0.54	1.33	1.84	47	0.32	0.52	0.55
10	0.34	0.40	0.45	48	0.96	7.50	10.40
11	1.62	2.10	–	49	0.24	0.42	0.46
12	0.74	2.50	4.63	50	0.18	0.19	0.24
13	0.94	1.56	3.00	51	–	–	–
14	1.04	2.10	2.90	52	0.72	1.12	4.52
15	0.38	0.55	0.85	53	0.44	1.04	1.08
16	2.00	3.35	3.75	54	1.32	3.50	9.10
17	1.16	1.70	2.00	55	0.80	0.92	1.28
18	2.64	4.90	9.20	56	0.60	–	–
19	0.28	0.55	–	57	1.04	4.00	5.40
20	0.58	–	–	58	0.40	0.43	0.67
21	–	–	–	59	1.24	1.82	–
22	0.58	2.05	2.10	60	1.80	1.84	2.84
23	0.48	1.25	1.35	61	1.54	1.92	2.06
24	0.28	2.75	4.65	62	0.76	1.96	3.88
25	2.10	3.90	–	63	1.04	1.82	5.82
26	0.94	2.30	3.60	64	0.52	1.30	2.28
27	2.98	5.35	–	65	–	–	–
28	0.32	0.35	0.85	66	0.36	0.50	0.68
29	0.34	1.24	2.20	67	1.30	2.20	3.36
30	1.58	5.50	16.35	68	2.14	2.50	3.34
31	0.94	2.50	2.55	69	2.44	–	–
32	0.64	0.80	2.20	70	0.30	0.38	0.45
33	1.30	3.40	4.75	71	2.78	–	–
34	1.14	2.65	2.75	72	0.68	0.84	0.94
35	0.78	0.85	0.90	73	0.68	1.52	2.28
36	2.64	4.10	4.15	74	0.40	0.45	1.66
37	1.74	2.50	2.68	75	0.49	0.68	2.02
38	0.24	0.90	–				

Applying these values in Kunkel's formula we calculate the differences:

$$\Delta M_V\ (T_{0.5}) = 0^{m}.31$$
$$\Delta M_V\ (T_{0.2}) = 2.16$$
$$\Delta M_V\ (T_{0.1}) = 3.42$$

Our results for $\langle \log T_{0.5} \rangle$ confirm Kunkel's empirical formula.

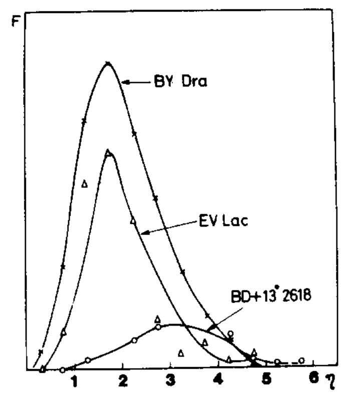

Figure 1

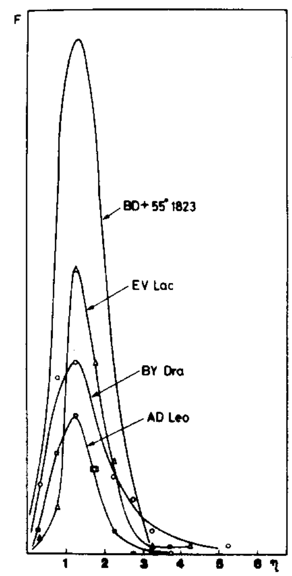

Figure 2

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Reference:

Kunkel, W.E.: 1973, Ap.J. Suppl. 25.1