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SOME PROBABLY REAL AND SOME PROBABLY SPURIOUS FLARES OF AD Leo

Photoelectric monitoring of AD Leo during the co-operative patrol period in March 1970 yealded six apparent flares, none of them dramatic. Three of these occurred at nearly identical hour angles suggesting that they are probably spurious.

Table I shows the distribution of actual monitoring time which totaled 15.91 hours. Differential measures were made each night with respect to the comparison star indicated in IBVS No. 326. These magnitude differences are listed at some sample times in Table II.

All photometry was done at Mt. Cuba Observatory using the same system as reported in IBVS No.363 except that an f/32 (rather than f/16) secondary mirror was used in the 61-cm diameter Cassegrain. This gave a less divergent beam through the Calcium K-line interference filter (70A wide).

Estimates of the signal to noise ratio I_0/σ (average nonflaring signal divided by standard deviation) in Table II are for the instrumental time constant which is between one and two seconds. Noise fluctuations as they appeared on the photometer chart have been faitfully reproduced in Figures 1 and 2 so as to avoid smoothing out possible fine structure within the flare curves. However, a spike to 3σ above quiescence would not be identified as a flare unless it remained at this elevated level for at least five or ten seconds. Therefore, the quantity tabulated as $m_{lim}-m_0 = 2.5 \log (I_0/3\sigma)$ is based on a time constant more realistically assumed to be five times longer than the instrumental time constant, making the standard deviation $1/\sqrt{5}$ times smaller in this equation.

Table II shows measurements of AD Leo at times that appeared to be representative of the quiescent star. AD Leo is seen to average 1.34 mag fainter than the comparison star with a range of ± 0.15 mag among the 18 measures. Thirteen noise estimates show the instrumental I_0/σ to vary from 4.4 to 8.1 with an average of 6.12, corresponding to $m_{lim}-m_0 = 1.65$.

In Table III the universal time is listed for the moment of peak intensity of each flare and suspected flare. The duration of elevated brightness before the peak and after the peak are indicated by t_b and t_a respectively. The change in magnitude of the flare star is denoted Δm and the

Table I. Coverage of AD Leo during March, 1970.
Times are rounded to the nearest minute of UT

March	UT Coverage
1	3^h31^m-33^m, 3:37-54, 4:06-17, 4:20-29, 4:32-35, 4:37-46, 4:48-52, 4:54-57, 5:00-02, 5:18-20, 5:23-34, 5:40-50, 5:55-6:05, 6:07-19, 6:27-41, 6:44-56, 6:59-7:13, 7:19-31, 7:49-8:06, 8:11-25.
8	2:02-07, 2:11-22, 2:25-39, 2:43-52, 3:06-13, 3:19-29, 3:32-40, 3:44-47, 5:05-13, 5:16-29, 5:33-40, 5:43-51, 5:53-6:04, 6:06-15, 6:19-25, 7:37-43.
9	2:58-3:00, 3:30-34, 3:42-53.
10	2:14-23, 2:25-26, 2:29-42, 2:46-58, 3:02-16, 3:19-34, 3:40-53, 3:56-4:16, 4:35-49, 4:55-5:19, 5:26-42, 5:49-6:03, 6:09-29, 6:36-54, 6:59-7:26, 7:31-51, 7:54-8:06, 8:08-10, 8:14-27.
12	1:58-2:00, 2:03-11, 2:16-31, 2:35-48, 2:52-3:05, 3:11-28.
15	0:57-1:07, 1:09-20, 1:24-39, 1:41-56, 1:59-2:09, 2:11-26, 2:29-42, 2:44-57, 2:58-3:11, 3:12-23, 3:28-40, 3:42-54, 3:56-4:06, 6:24-31, 6:36-46, 6:48-7:02, 7:10-21, 7:23-31, 7:34-36, 7:42-53, 7:58-8:10, 8:12-25, 8:31-46, 8:48-55, 8:57-58.

difference in magnitude between the comparison star and the flare star at its peak is denoted $m_c - m_{o+f}$. The difference in magnitude between the light from the flare at its maximum and that from the quiescent star (I_o) is computed from the brightness of their combined light (I_{o+f}) at its peak using.

$$(m_f - m_o)_{max} = -2.5 \log \left(\frac{I_{o+f} - I_o}{I_o} \right)$$

Near each flare a limiting magnitude of flare detectability is estimated ($m_{lim} - m_o$) in the same manner as was done for Table II. The integrated intensity P is computed (by planimetry) as recommended in IBVS No.326.

Events 3 and 6 have initial peaks at identical siderealtimes (hour angle = $1^h57^m.7$ E) within the accuracy of reading the chart recordings (universal times as originally read from the chart to 0.1 min convert to sidereal times differing by only two seconds). The first peak of Event 4 is 2.2 min earlier but an equally high peak that

Table II. Magnitude differences (using the 3903-3973A filter) between the comparison star and AD Leo during moments of apparent quiescence and estimates of noise in the AD Leo signal.

1970 March	UT	m_c-m_o	UT	$\frac{I_o}{\sigma}$	$m_{lim}-m_o$
1	4:02	1.38	*4:12	6.92	1.78
	5:48	1.36	*7:02	6.15	1.65
	6:35	1.32	8:02	4.80	1.38
	8:02	1.48			
8	2:31	1.25	*2:36	5.54	1.54
	3:42	1.42	6:01	7.42	1.86
	5:28	1.19			
9	3:32	1.30	3:32	6.89	1.78
10	2:12	1.29	*2:39	8.14	1.96
	2:51	1.33	7:56	7.36	1.85
	4:42	1.37			
	5:15	1.38			
	7:14	1.40			
12	2:34	1.35	2:28	5.83	1.59
15	1:58	1.43	1:35	4.42	1.29
	4:05	1.35	*2:05	5.00	1.43
	6:38	1.22	6:28	6.28	1.68
	8:08	1.34	8:15	4.83	1.39

*Near a flare; $m_{lim}-m_o$ at this time used for Table III.

follows is at the coincident sidereal time. The only other date (both 1969 and 1970 seasons) on which monitoring of AD Leo was in progress at Mt. Cuba around this hour angle was 1970 March 12. On that date there is no evidence of brightening at the hour angle of the first peak of Event 4; however, a five minute interval to measure background sky and the comparison star was begun one minute later and, hence, one minute before the hour angle of the triply coincident peaks. Within this interval, a 1.9 min measure of the comparison star ($\sim$1!5 distant at position angle $\sim 350°$) does not appear elevated nor does the 1.8 min measure of the sky at a distance of $\sim$0!9 in position angle $\sim 315°$ from AD Leo. Although Event 4 may involve some intrinsic variation of AD Leo, the evidence is strong that stray light is entering the photometer at hour angle = $1^h51^m_.8$E when the telescope is aimed at AD Leo. At each of the only three times these conditions were met, a peak of $\Delta m = 0.32$ magnitude occurred within 0.1 min of that hour angle and an irregularly elevated signal was exhibited between hour angles 1:52E and 1:48E, as shown in Fig.3.

Table III. Flares* of AD Leo

No	1970 March	UT	t_b	t_a	Δm	m_c-m_{o+f}	$m_{lim}-m_o$	$(m_f-m_o)_{max}$	P (min)	Air mass
1	1	$4^h48^m.8$	?	20^m?	0.62	1.95	1.78	0.29	3	1.06
2	1	$7^h08^m.7$	$0^m.22$	$1^m.6$	0.50	1.98	1.65	0.60	0.24	1.24
3*	8	$2^h27^m.3$	$0^m.30$	4^m?	0.32	1.59	1.54	1.14	0.47	1.17
4*	10	$2^h17^m.2$	$1^m.8$	16^m	0.32	1.63	1.96	1.15	2.0	1.17
5	10	$2^h52^m.6$	$0^m.80$	$22^m.5$	0.47	1.77	1.96	0.68	2.5	1.11
6*	15	$1^h59^m.8$	$0^m.13$	15^m	0.33	1.73	1.43	1.14	1.6	1.17

*N.B. The events designated with an asterisk in the first column all occurred at the same orientation of the telescope and are, therefore, suspected to be spurious.

Remarks (referred by No. in Table III):

(1) The beginning of the flare was missed because of centering problems; however, it is unlikely to have begun earlier than 4^h47^m. Also it is remotely possible that a principal peak could have occurred between $4^h48^m.1$ and $4^h48^m.5$ while the star was being recentered.

(2) Signal and noise portrayed in Fig.1. Light cloud cover.

(3) Noisy signal. At 0.7 min after the peak the signal dropped below I_0 for 0.1 min as shown in Fig.3.

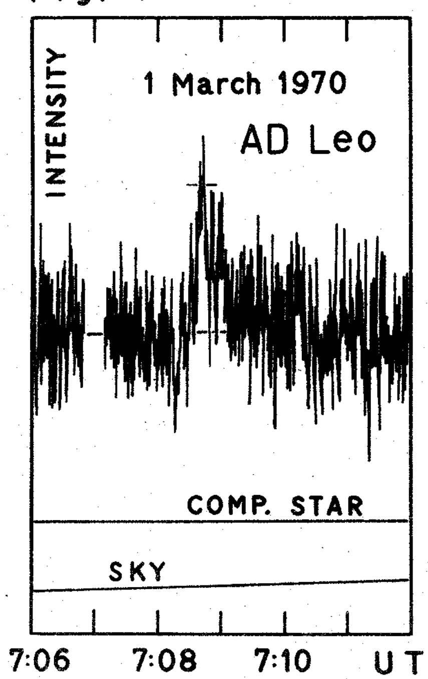
(4) This variable elevated signal occurred soon after monitoring began. Thus, the prior quiescent level is poorly established.

(5) Signal and noise portrayed in Fig.2. The most unambiguous flare in this Table. Signal continued at an elevated level of m_c-m_{o+f} = 1.38 from 3^h02^m to 3^h13^m, then dropped to 1.31 by 3^h15^m.

To create Figure 3, eye estimates of the mean intensity I_{o+f} were made within independent 0.2 min intervals successively along the photometer chart. The quiescent intensity I_0 was interpolated linearly from regions that typically were several minutes long and just outside the figure.

Although several faint working lights are usually on at fixed locations in the dome, none is known to leak light into the photometer. The possibility that a discrete ray can, after several chance reflections at a particular setting of the telescope, find its way to the electrically and magnetically shielded photomultiplier must be investigated. Electrical noise associated with attitude of the telescope is not considered likely. It may be pertinent that

Fig. 1



the 1.8 mag star γ Leo is only 5' away. An attempt will be made to trace the effect during the coming observing season of AD Leo.

Andrews (1968) has pointed out that an analysis of over 100 flares recorded at several different observatories showed 17% of the flares to occur within 1 min of the same sidereal time as another flare. Events 3, 4, and 6 of Table III are the only coincidences so far found at Mt.Cuba Observatory. Of the ten flares of DO Cep observed in 1968 (IBVS No.329) no two were at the same sidereal time. Furthermore, for each sidereal time at which a flare occurred there were at least two other nights on which monitoring was in progress at that moment of sidereal time and no flare was seen. These statements are also true for AD Leo Events 1, 2, and 5 in Table III although No.2 happens to have occur-

Fig. 2

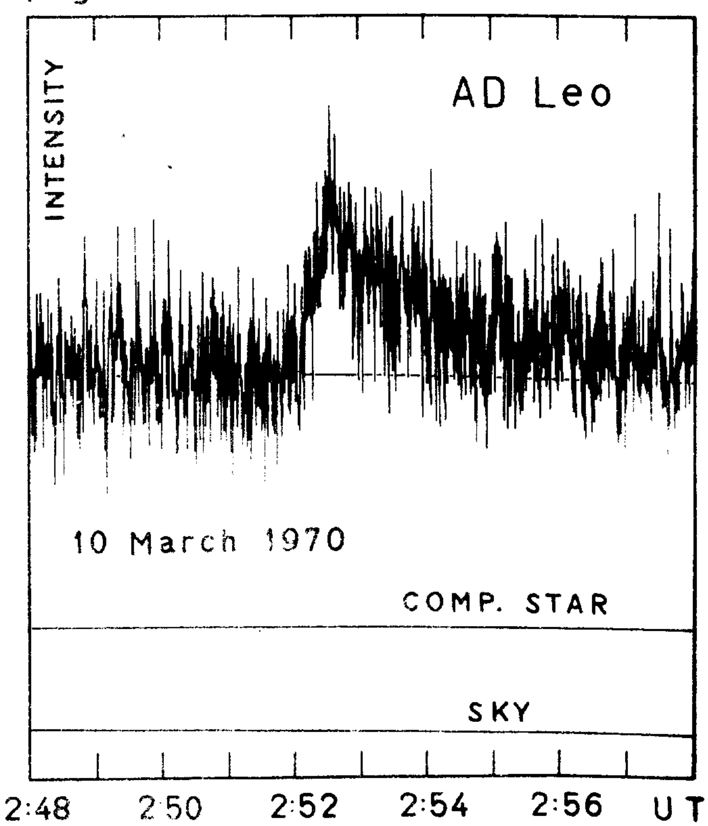
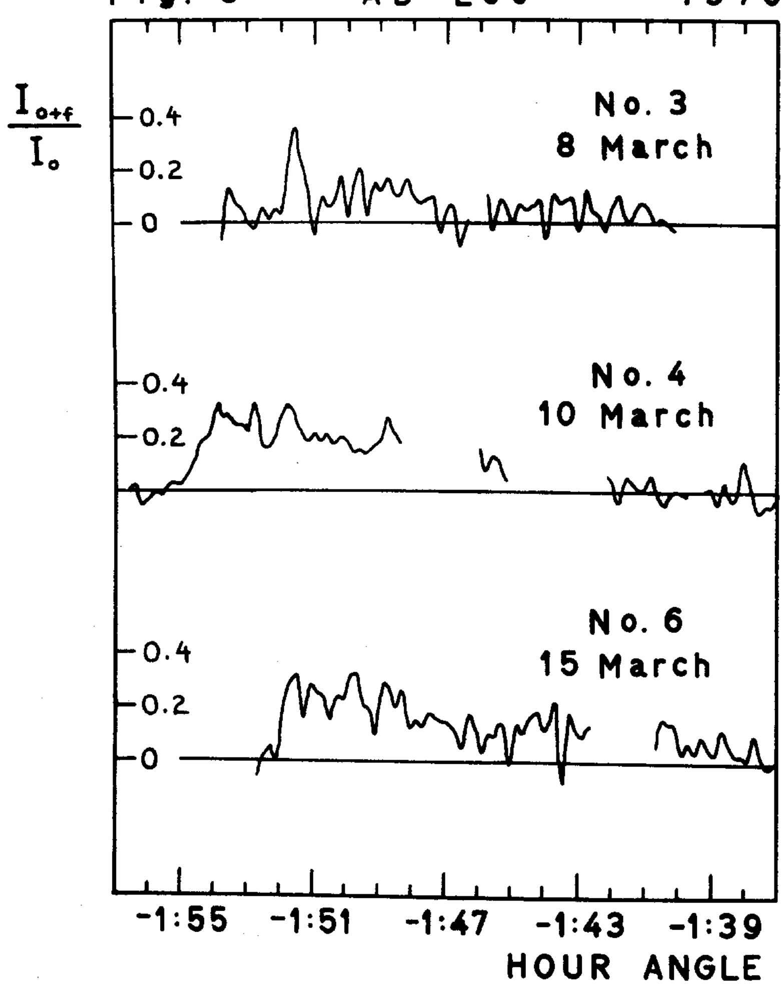

AD Leo
INTENSITY
10 March 1970
COMP. STAR
SKY
2:48
2:50
2:52
2:54
2:56
UT

Fig. 3 AD Leo 1970



red at the same hour angle as one of the DO Cep flares (No.5).

Although all three of the apparently spurious flares (3, 4, 6) were noted to be "dubious" on a preliminary table, each, by itself, would have been reported as a possible flare with a notation of uncertainty. It was only the coincidence of three similar events at the same hour angle that commanded consideration of their probably nonstellar nature. Photoelectric observers of variable stars are advised to check the times of erratic brightenings for such coincidences.

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