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PHOTOELECTRIC OBSERVATIONS OF THE FLARE STAR AD Leo IN 1982

Photoelectric observations of flare stars have been continued at the National Astronomical Observatory of the Bulgarian Academy of Sciences. In this paper we report about our observations of the flare star AD Leo in 1982.

The observations were carried out with the 60 cm Cassegrain reflector and the one channel U,B,V photoelectric photometer. A photon counting system with an integration time of 1 sec was used. Details of this equipment are published by Panov et al. (1982). Here we give the transformation of the instrumental u,b,v system to the international U,B,V system for the period under consideration:

$$\Delta V = \Delta v + 0.10\Delta(b-v)$$
$$\Delta(B-V) = 1.13\ \Delta(b-v)$$
$$\Delta(U-B) = 0.84\ \Delta(u-b)$$

Monitoring observations were carried out on 6 nights in February and March 1982 in colour "u". Table I contains, for each night, the monitoring intervals in UT, the number of flares observed, as well as the total monitoring time.

During the total of 17^h57^m monitoring time 23 flares were observed, the characteristics of which are given in Tables II-VII. For each flare the following characteristics (Andrews et al., 1969) are given:

a. the date and universal time of maximum.

b. the duration before and after maximum (t_b and t_a, respectively.

c. the total duration of the flare.

Table I

Flare star AD Leo, 1982

Date	Monitoring intervals (U.T.)	Total monit. time	Number of flares
1982			
Febr.			
16/17	$21^h12^m01^s$–$23^h11^m24^s$,		
	23 15 17 –00 18 58 .	$3^h03^m04^s$	5
18	20 32 13 –21 55 24 ,		
	21 56 19 –22 19 56 ,		
	22 21 18 –23 38 09 .	3 03 39	5
March			
18	20 50 14 –23 00 18 .	2 10 04	1
25	19 10 54 –19 27 55 ,		
	19 29 58 –22 58 22 .	3 45 25	7
26	18 49 50 –19 22 19 ,		
	19 24 07 –20 56 19 ,		
	20 57 55 –21 19 55 ,		
	21 29 31 –22 31 46 .	3 28 56	3
27	19 00 52 –20 13 25 ,		
	20 28 14 –20 55 36 ,		
	21 57 46 –22 43 25 .	2 25 34	2
	Total:	$17^h56^m42^s$	23

Table II

Characteristics of the flares observed on February 16, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$21^h46^m27^s$	0.18	1.1	1.3	1.18	0.18	0.03	0.07	1.108
2	21 59 26	0.13	2.0	2.1	1.48	0.42	0.03	0.22	1.095
3	22 58 31	0.38	1.5	1.9	1.25	0.24	0.03	0.16	1.074
4	23 37 55	0.67	0.7	1.4	1.20	0.20	0.03	0.10	1.090
5	23 57 00	0.30	4.0	4.3	1.66	0.55	0.03	1.09	1.107

Table III

Characteristics of the flares observed on February 18, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$21^h15^m20^s$	0.33	4.7	5.0	2.81	1.12	0.03	1.33	1.139
2	22 07 15	0.42	0.8	1.2	1.19	0.19	0.03	0.09	1.085
3	22 09 24	1.0	1.0	2.0	1.22	0.21	0.03	0.13	1.084
4	22 21 44	0.27	2.3	2.6	1.38	0.35	0.03	0.17	1.078
5	22 51 52	0.57	1.1	1.7	1.17	0.17	0.03	0.11	1.074

Table IV

Characteristics of the flare observed on March 18, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$20^h53^m00^s$	0.28	1.5	1.8	1.29	0.28	0.03	0.19	1.074

Table V

Characteristics of the flares observed on March 25, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$19^h34^m55^s$	0.82	10.0	11.0	2.79	1.12	0.03	3.81	1.095
2	20 14 50	1.00	6.0	7.0	1.74	0.60	0.03	2.04	1.075
3	21 31 00	0.67	1.5	2.2	1.46	0.41	0.03	0.33	1.106
4	21 41 56	0.10	2.0	2.1	1.41	0.37	0.03	0.23	1.118
5	21 54 58	2.63	14.0	16.6	2.18	0.85	0.03	8.75	1.136
6	22 26 58	0.55	2.0	2.6	1.44	0.40	0.03	0.39	1.194
7	22 51 52	Duration = 2 sec			1.47	0.42	0.03	0.01	1.256

Table VI

Characteristics of the flares observed on March 26, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$19^h11^m30^s$	1.5	23.0	24.5	2.93	1.17	0.03	21.05	1.115
2	20 47 13	0.80	9.0	9.8	5.33	1.82	0.03	7.61	1.078
3	22 27 34	0.12	0.4	0.5	1.36	0.33	0.03	0.06	1.203

Table VII

Characteristics of the flares observed on March 27, 1982

Flare No	U.T. max	t_b min	t_a min	Duration min	I_f/I_o max	Δm mag	σ mag	P min	Air mass
1	$19^h38^m35^s$	0.42	1.5	1.9	1.71	0.58	0.03	0.19	1.092
2	22 30 08	0.13	0.7	0.8	1.61	0.52	0.03	0.05	1.198

d. The value of ratio I_f/I_o, corresponding to flare maximum, where I_f is the total intensity of the star plus flare less sky background and I_o is the quiet state intensity of the star less sky background.

e. the increase of star's brightness in magnitudes at flare maximum:

$$\Delta m(u) = 2.5 \log I_f/I_o$$

where "u" is the instrumental ultraviolet magnitude.

f. the standard deviation of random noise fluctuations in mag:

$$\sigma(\text{mag}) = 2.5 \log \frac{I_o+\sigma}{I_o}$$

g. the integrated intensity of the flare over its total duration:

$$P = \int (I_f - I_o)/I_o \, dt$$

h. the air mass.

The light curves in colour "u" are shown in Figures 1-23. Every point on the figures represents 1 sec integration of intensity.

The distribution of amplitudes of the observed flares is shown in Table VIII.

Table VIII

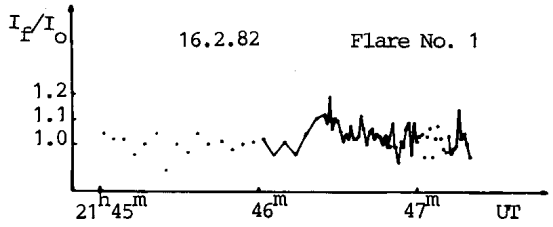
Distribution of the amplitudes of the flares observed

	Amplitudes Δm			
	$0^m.15$-$0^m.5$	$0^m.5$-$1^m.0$	$1^m.0$-$1^m.5$	$1^m.5<$
Number of flares	14	5	3	1

Previous observations of AD Leo by other observers (Moffett, 1974) revealed a frequency of flare occuring of about 1 flare per 3 hours monitoring time (in colour "u"). In the period under consideration we observed about 3 times higher frequency of flare occuring, which means that in that period AD Leo was in a state of enhanced flare activity. Comparison with observations of the star by other observers during the same time would be most desirable.

We observed pre-flare decrease of brightness only in two cases. Flare No.1 of 18.3.1982 has a pre-flare decrease of 0.07 mag and duration of 5 sec, and flare No.4 of 25.3.1982 has a pre-flare decrease of 0.10 mag and duration of 20 sec. It should be stressed, however, that pre-flare decreases of brightness can only be secured by synchronous observations by two or more telescopes.

The comparison star BD+20^{o}2464 was observed on each night listed in Table I, several times in U,B,V, in order to search for long-term brightness variability of AD Leo. For the period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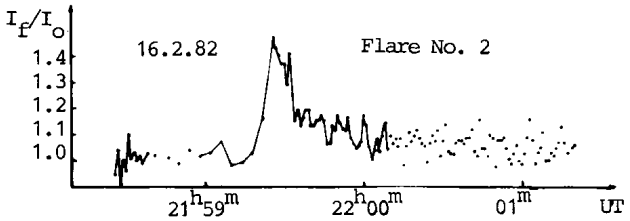
1.0
21^h45^m
46^m
47^m
UT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1.2
1.1
1.0
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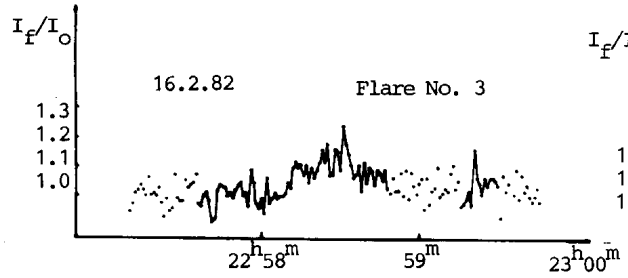
22^h00^m
01^m
UT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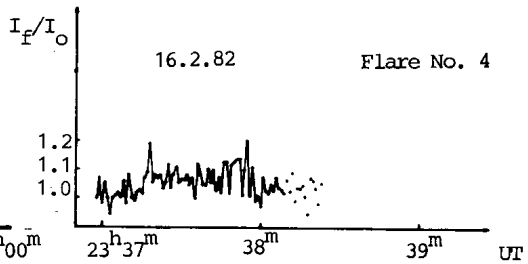
1.2
1.1
1.0
22^h58^m
59^m
23^h00^m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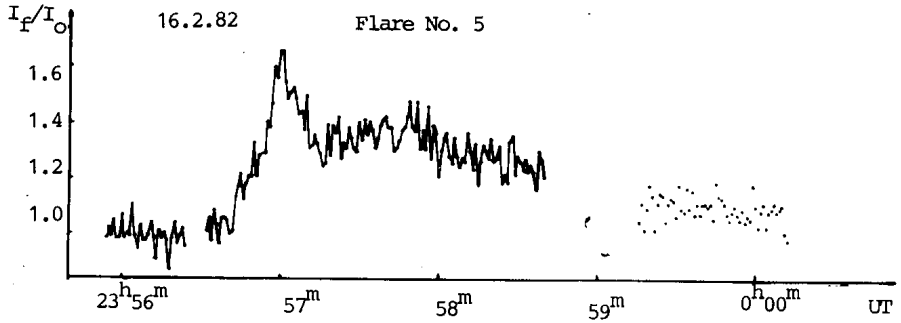
1.1
1.0
23^h37^m
38^m
39^m
UT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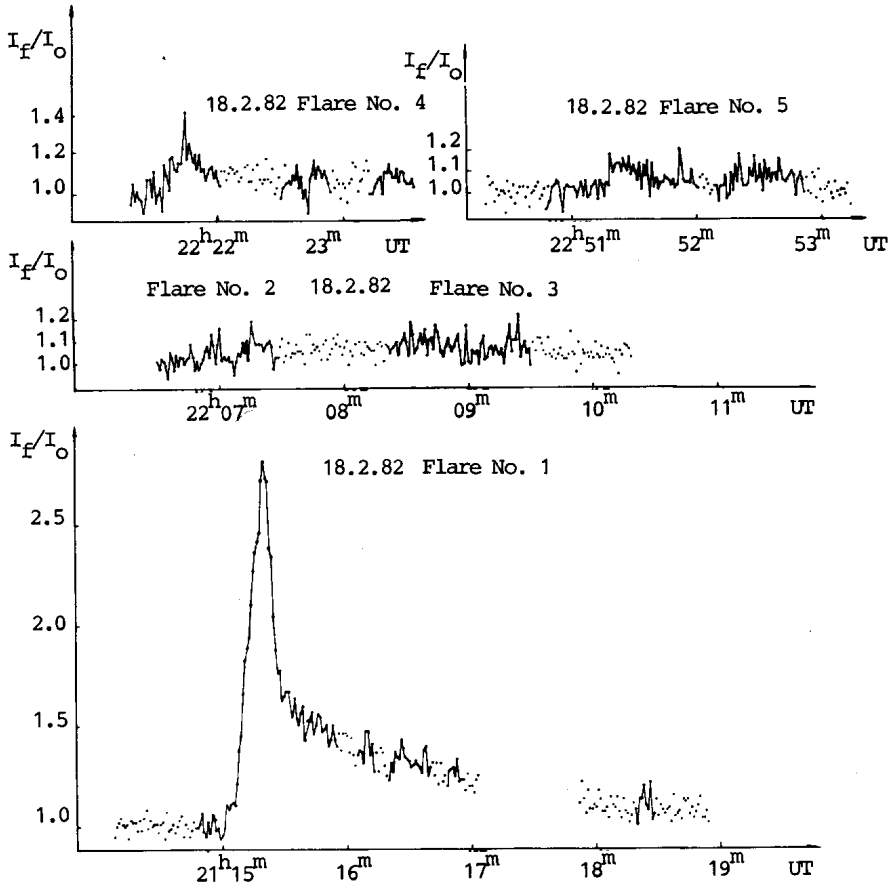
57^m
58^m
59^m
0^h00^m
UT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1.4
1.2
1.0
22^h22^m
23^m
UT
I_f/I_o
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1.2
1.1
1.0
22^h51^m
52^m
53^m
UT
I_f/I_o
Flare No. 2
18.2.82
Flare No. 3
1.2
1.1
1.0
22^h07^m
08^m
09^m
10^m
11^m
UT
I_f/I_o
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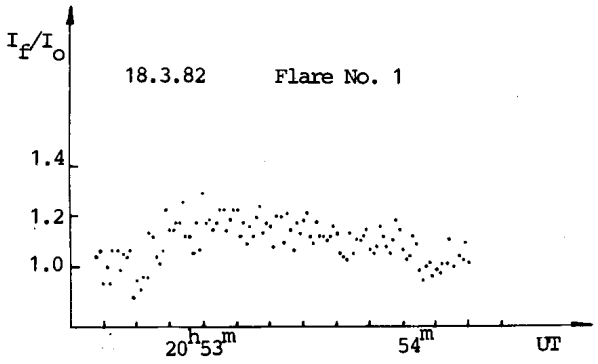
17^m
18^m
19^m
UT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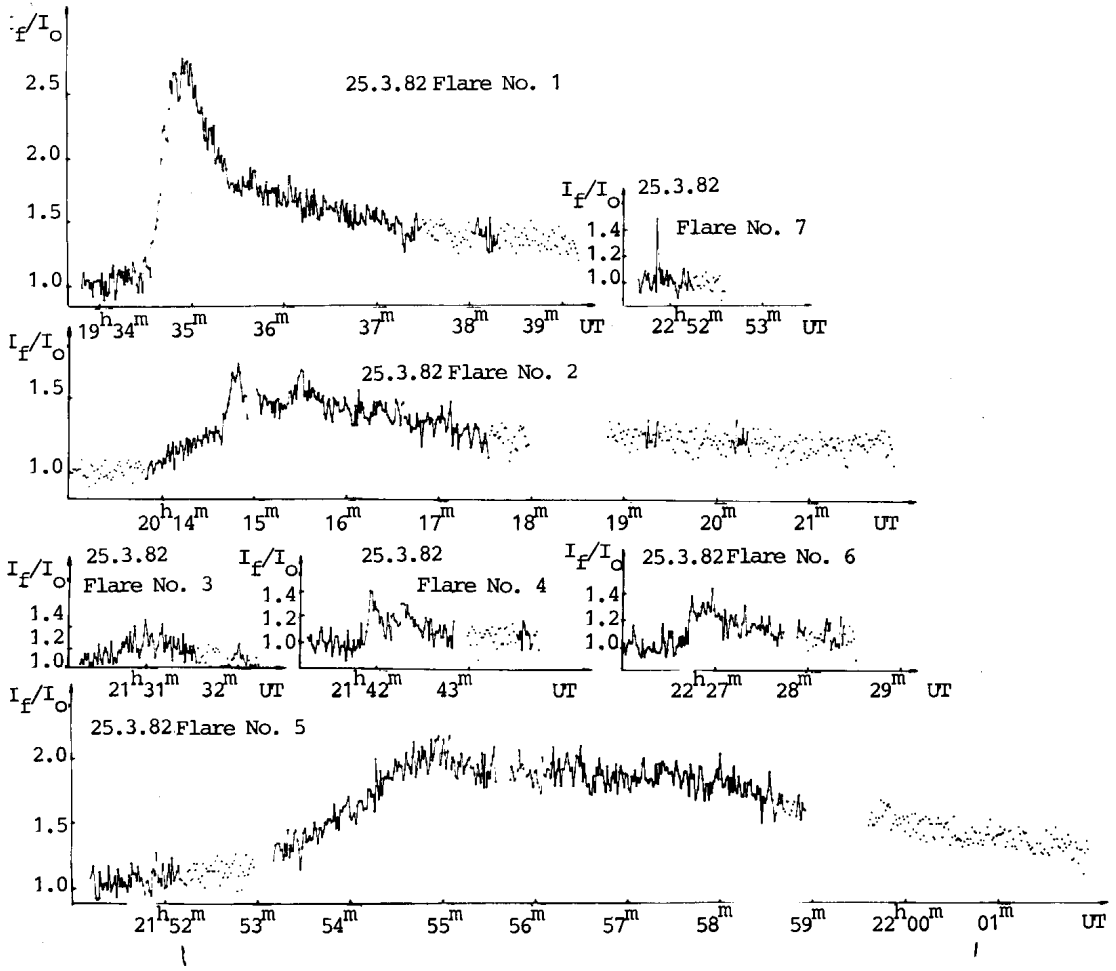
1.0
20^h53^m
54^m
UT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2.0
1.5
1.0
19^h34^m 35^m 36^m 37^m 38^m 39^m UT
I_f/I_o 25.3.82
Flare No. 7
1.4
1.2
1.0
22^h52^m 53^m UT
I_f/I_o
25.3.82 Flare No. 2
1.5
1.0
20^h14^m 15^m 16^m 17^m 18^m 19^m 20^m 21^m UT
I_f/I_o 25.3.82
Flare No. 3
1.4
1.2
1.0
21^h31^m 32^m UT
I_f/I_o 25.3.82
Flare No. 4
1.4
1.2
1.0
21^h42^m 43^m UT
I_f/I_o 25.3.82 Flare No. 6
1.4
1.2
1.0
22^h27^m 28^m 29^m UT
I_f/I_o
25.3.82 Flare No. 5
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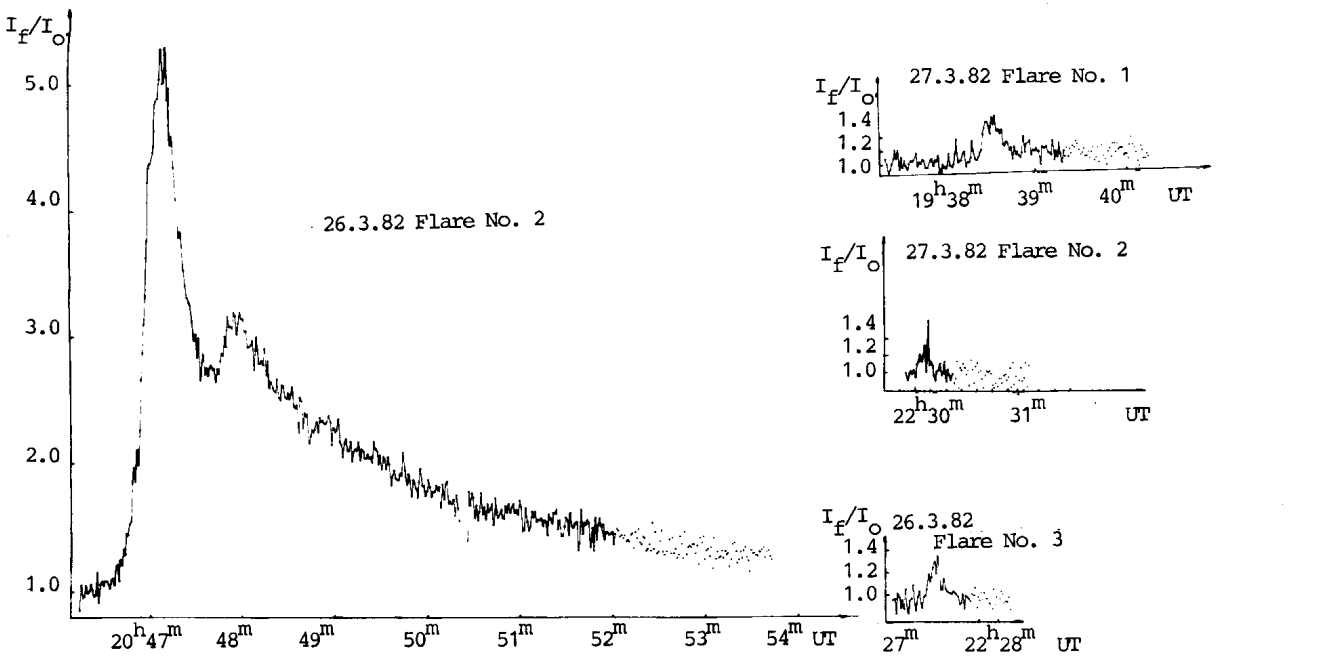
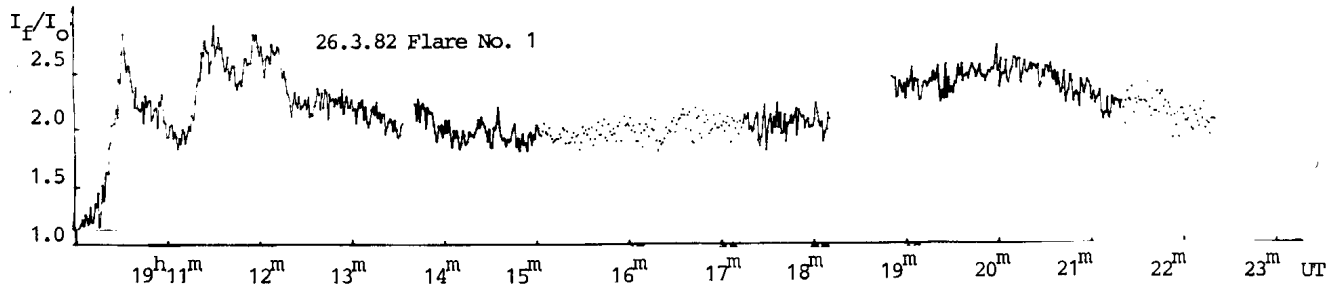
1.5
1.0
21^h52^m 53^m 54^m 55^m 56^m 57^m 58^m 59^m 22^h00^m 01^m UT


I_f/I_o
5.0
4.0
3.0
2.0
1.0
26.3.82 Flare No. 2
20^h47^m 48^m 49^m 50^m 51^m 52^m 53^m 54^m UT

I_f/I_o
27.3.82 Flare No. 1
1.4
1.2
1.0
19^h38^m 39^m 40^m UT

I_f/I_o
27.3.82 Flare No. 2
1.4
1.2
1.0
22^h30^m 31^m UT

I_f/I_o
26.3.82
Flare No. 3
1.4
1.2
1.0
27^m 22^h28^m UT


I_f/I_o
26.3.82 Flare No. 1
2.5
2.0
1.5
1.0
19^h11^m 12^m 13^m 14^m 15^m 16^m 17^m 18^m 19^m 20^m 21^m 22^m 23^m UT

under consideration, no significant changes in the quiet state U,B,V, brightness of AD Leo were found. Thus, the remarkable flare activity of AD Leo in 1982 was not connected with quiet state brightness variability.

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