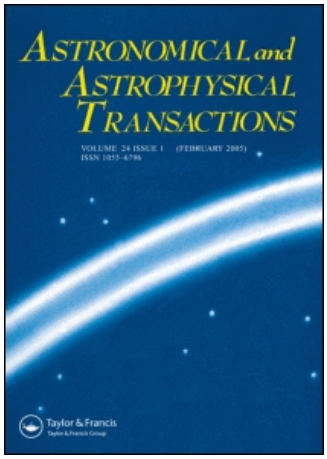

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Light curve of on 231 in the period 1969-1976

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LIGHT CURVE OF ON 231 IN THE PERIOD 1969–1976

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A light curve of the BL Lac-type object ON 231 in the period from 1969 to 1976 is presented. Our photometric data enlarge by a factor of 2 the existing data on this object. Variability on the time scale of minutes is suspected.

Keywords: BL Lac-type objects, ON 231, Variability

1 INTRODUCTION

The brightness variability is known to be an indispensable characteristic of the BL Lac-type objects: lacertides. The origin of this variability has not been quite clear up to now. That is why further variability studies will enable the nature of these objects and the mechanisms responsible for the observed activity to be revealed.

Despite intensive observations of some objects of this type made in recent years the brightness estimations are not often enough even for a description of all variability details.

ON 231 (or alternatively called W Comae) (right ascension $12^{\mathrm{h}}\,19^{\mathrm{m}}\,01.1^{\mathrm{s}}$; declination, $+28^{\circ}\,30'\,37''$; 1950.0; $z = 0.102$) is a well-known lacertide, whose brightness variability was discovered in 1916 (Wolf, 1916), long before the specification of its intrinsic physical nature. Now it has been investigated rather well. For example, in the National Aeronautics and Space Administration–Extragalactic Database (NED), more than 200 references on this object have already been recorded. Nevertheless, over the past few years, intensive photometric observations in different spectral regions are conducted in the frameworks of international programmes in an effort to construct a more detailed light curve (Massaro *et al*., 1999; Katajainen *et al*., 2000).

Photometric data about this object on archival photographic plates is definitely also of great interest.

2 OBSERVATIONS AND DATA REDUCTION

For investigation of the brightness variations of ON 231 we used observational material, obtained for monitoring flare stars in the Coma star cluster. This is a collection of photographic

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plates obtained during the period from 1969 to 1976 with the 21″–21″ Schmidt telescope of the Byurakan Astrophysical Observatory (Armenia). The photographic plates were obtained on Kodak 103aO, Kodak IIaO, Orwo ZU2 and Orwo ZU21 emulsions on the basis of multiple exposures or the 'chain' technique; some images appeared on each plate, shifted along the right ascension direction with the same exposures, which varied from plate to plate within 5–10 min.

Usually such a plate was exposed for about an hour. Clouds, poor visibility and other unforeseen circumstances resulted in a reduction in the full exposure.

All plates were examined by eye with 7× and 10× eyeglasses. Comparison stars in the field of ON 231 from the work by Wing (1973), Pollock *et al*. (1974) and Belokon' and Babadjanjanz (2000) were used. The star F was excluded from consideration because it turned out to be variable with an amplitude of 1.1 (16.4–17.5) in photographic light. Variability of star was suspected in the work by Veron and Veron (1975). Our best-quality plates have a limiting magnitude of about 18^{m}. Nevertheless in some cases the brightness of the investigated object was found to be close to the limiting magnitude of the plate.

3 RESULTS

Results of the present investigation of the optical variability of ON 231 are summarized in Table I. The mean photographic magnitude for each plate for the Julian day (JD), corresponding to the middle of the full exposure is given.

The amplitude magnitude of the light variations during our observational period is $m(\mathrm{pg}) = 1.6$ in the brightness interval from 16.1 to 17.7 in photographic light.

Table I presents the following data:

(i) date of observation for each plate (Universal time (UT));
(ii) the heliocentric JD corresponding to the middle of the multiple exposure for each plate;
(iii) photographic magnitudes with an accuracy about 0.07. The letter v means that the light variations are seen along the multiple exposure on a time scale of 5–10 min;
(iv) number of exposures and duration of each exposure in minutes.

A light curve of ON 231 is presented in Figure 1. The data in Figure 1 are averaged for each JD. ON 231 reached its absolute light minimum on 15 April, 1972, when its brightness magnitude during the whole night was $m(\mathrm{pg}) = 17.7$. The brightness changes from night to night irregularly.

Figure 2 presents the mean magnitudes for each year. The long-term regular trend in brightness behaviour is evident: decreasing before 1972–1973 and step by step increasing to 1976, although the dispersion is rather large which testifies to the light variations on a time scale of days, hours and even minutes. On the other hand, this dispersion probably depends on the number of observations during the observational set for each year. This can be seen in Figure 3 which shows the dependence of the rms average magnitude for a year upon the number of all observations of ON 231 for the same year. It probably demonstrates that, for a more precise performance of the light curve shape, more observational points are needed. By a comparison with the historic summary light curve presented in the work by Belokon' and Babadjanjanz (2000), Tosti *et al*. (1998) showed that our observations, in general, are in good agreement. Our photometric estimations double the amount of observational material existing previously. In 1972–1973 the lacertide reached its minimum brightness. The variability is presented by irregular light variations on a time scale of months, days and even hours. Also, in some cases we found real light variations of both irregular and systematic character on a time scale of 5–10 min with a magnitude as great as approximately $0.3\,\mathrm{h}^{-1}$.

TABLE I

N	*Date (U.T.)*	*J.D. 244 0000+*	*m (pg)*	*Exp.*
1	18.04.1969	0329.320	16.10	10 × 5
2		0329.416	16.10	10 × 5
3	22.04.1969	0333.427	16.24	4 × 5
4	09.05.1969	0350.277	16.41	10 × 5
5		0350.344	16.41	6 × 5
6		0350.407	16.4	1 × 5
7		0350.550	16.37	4 × 10
8	07.03.1970	0653.440	16.40	6 × 10
9	08.03.1970	0654.337	16.77	6 × 10
10		0654.453	16.86	6 × 10
11	09.03.1970	0655.004	16.72	5 × 10
12	01.06.1970	0738.267	16.70	6 × 10
13		0738.318	16.96	7 × 10
14	20.03.1971	1030.401	16.60	6 × 10
15		1030.454	16.45	5 × 10
16	22.03.1971	1032.398	16.42	6 × 10
17		1032.447	16.60	6 × 10
18		1032.496	16.60	6 × 10
19	28.03.1971	1038.354	16.42	6 × 10
20		1038.404	16.43	6 × 10
21		1038.452	16.43	6 × 10
22	29.03.1971	1039.001	16.38	6 × 10
23	24.04.1971	1065.286	16.89	1 × 45
24	25.04.1971	1066.278	16.99	1 × 60
25		1066.310	17.20	6 × 10
26		1066.377	16.72	1 × 30
27		1066.408	17.21	6 × 10
28	27.04.1971	1068.279	17.22	6 × 10
29		1068.327	17.08	6 × 10
30		1068.374	16.94	6 × 10
31		1068.423	17.20	6 × 10
32	28.04.1971	1069.288	17.10	6 × 10
33		1069.337	16.99	6 × 10
34		1069.385	17.22	6 × 10
35		1069.432	17.22	6 × 10
36	24.05.1971	1095.338	17.00	6 × 10
37	13.06.1971	1115.260	16.70	6 × 10
38	17.06.1971	1119.260	17.16	6 × 10
39	19.06.1971	1121.267	17.13	6 × 10
40	23.06.1971	1125.260	16.70	6 × 10
41	18.01.1972	1334.479	17.13	6 × 10
42	15.02.1972	1362.371	16.50	3 × 10
43	19.02.1972	1366.482	16.41	6 × 10
44	20.02.1972	1367.034	16.5	3 × 10
45	09.03.1972	1385.488	16.40	10 × 5
46	10.03.1972	1386.490	16.4	10 × 5
47	11.03.1972	1387.032	16.4	4 × 5
48	16.03.1972	1392.427	16.4	8 × 5
49		1392.472	16.4	8 × 5

(*continued*)

TABLE I Continued.

N	*Date (U.T.)*	*J.D. 244 0000+*	*m (pg)*	*Exp.*
50	20.03.1972	1396.466	17.18	12 × 5
51	21.03.1972	1397.015	16.74	12 × 5
52	04.04.1972	1411.348	17.22	6 × 10
53	06.04.1972	1413.411	17.13	12 × 5
54		1413.458	17	6 × 5
55	07.04.1972	1414.390	16.4	1 × 25
56	08.04.1972	1415.343	17.21	6 × 10
57		1415.392	17.21	6 × 10
58	13.04.1972	1420.393	17.3	1 × 16
59		1420.417	17.23	1 × 25
60	14.04.1972	1421.388	17.23	12 × 5
61		1421.436	17.1	12 × 5
62		1421.484	17.1	12 × 5
63	15.04.1972	1422.351	17.71	6 × 10
64		1422.402	17.71	6 × 10
65		1422.453	17.71	6 × 10
66	16.04.1972	1423.375	17.71	8 × 10
67	17.04.1972	1424.369	17.22	5 × 10
68		1424.441	17.22	7 × 10
69	08.05.1972	1445.296	17.23	8 × 10
70	10.05.1972	1447.304	17.10	5 × 10
71	30.05.1972	1467.347	17.22	5 × 10
72	31.05.1972	1468.346	17.22	6 × 10
73	03.06.1972	1471.322	16.41	7 × 10
74	05.06.1972	1473.308	16.58	6 × 10
75	09.02.1973	1722.443	17.13	5 × 10
76	10.02.1973	1723.408	16.77	5 × 10
77		1723.451	16.50	5 × 10
78		1723.494	16.98	5 × 10
79	11.02.1973	1724.019	17.22	5 × 10
80	27.02.1973	1740.869	17.22	5 × 10
81		1740.438	16.84	4 × 10
82	28.02.1973	1741.414	16.94	5 × 10
83		1741.458	16.94	2 × 10
84	04.03.1973	1745.274	17	5 × 10
85		1745.318	17.21	5 × 10
86		1745.368	17.71	5 × 10
87		1745.410	17.22	5 × 10
88		1745.458	17.22	5 × 10
89	05.03.1973	1746.006	17.22	6 × 10
90		1746.046	17.29	6 × 5
91	06.03.1973	1747.279	17.20	6 × 10
92		1747.328	17.33v	5 × 10
93		1747.370	17.47	1 × 10
94		1747.416	17.39	5 × 10
95		1747.459	17.2	7 × 10
96	07.03.1973	1748.017	17.2	7 × 10
97	08.03.1973	1749.349	17.22	7 × 10
98		1749.405	17.2	7 × 10

(*continued*)

TABLE I Continued.

N	*Date (U.T.)*	*J.D. 244 0000+*	*m (pg)*	*Exp.*
99		1749.463	17.38	7 × 10
100	09.03.1973	1750.019	17.2	7 × 10
101	10.03.1973	1751.396	17.18	7 × 10
102	05.04.1973	1777.381	16.74	7 × 10
103	09.04.1973	1781.271	16.46	5 × 10
104		1781.315	16.24	5 × 10
105		1781.358	16.10	5 × 10
106		1781.401	16.10	5 × 10
107		1781.446	16.10	5 × 10
108		1781.490	16.20	5 × 10
109	10.04.1973	1782.384	16.30	6 × 5
110	30.04.1973	1802.281	17.13	5 × 10
111		1802.329	17.22	2 × 10
112		1802.403	16.97	5 × 10
113	01.05.1973	1803.264	17.16	7 × 10
114		1803.326	16.81v	4 × 10
115	21.05.1973	1824.257	16.53	6 × 10
116		1824.306	16.60	4 × 10
117	24.05.1973	1827.266	17.21	7 × 10
118	12.05.1974	2180.278	16.98	6 × 10
119		2180.335	16.84	6 × 10
120	15.05.1974	2183.265	16.53	6 × 10
121		2183.313	16.60	5 × 10
122	17.05.1974	2185.292	16.79	6 × 10
123		2185.340	16.79	6 × 10
124	18.05.1974	2186.263	16.60	5 × 10
125		2186.306	16.98	5 × 10
126	24.05.1974	2192.246	16.98	5 × 10
127		2192.330	16.52	7 × 5
128		2192.364	16.43v	6 × 5
129	25.05.1974	2193.269	16.53	6 × 5
130		2193.297	16.47	6 × 5
131		2193.325	16.28	6 × 5
132	09.06.1974	2208.261	17.21	8 × 5
133	10.06.1974	2209.264	17.21	8 × 5
134	11.06.1974	2210.273	17	8 × 5
135	14.06.1974	2213.267	17.21	8 × 5
136	22.03.1976	2860.306	16.26	1 × 15
137		2860.340	16.30	1 × 20
138		2860.363	16.18	1 × 30
139	26.03.1976	2864.352	16.11	1 × 10
140		2864.366	16.10	1 × 10
141		2864.378	16.11	1 × 10
142		2864.391	16.11	1 × 10

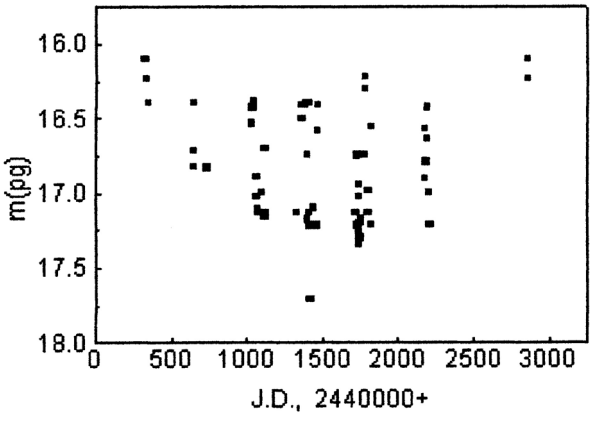

FIGURE 1 The light curve of ON 231, mean data for each JD.

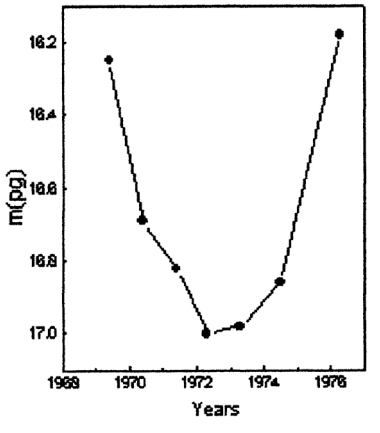

FIGURE 2 The mean magnitudes of ON 231 for each year.

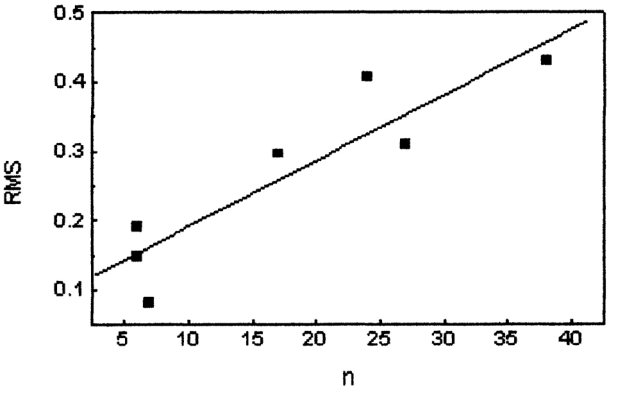

FIGURE 3 Rms average magnitude for a year as a function of the number of light points during the same year.

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