LONG-TERM VARIABILITY OF THE NOVA–LIKE VARIABLE V SGE

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ABSTRACT. V Sge was studied on photonegatives of the Moscow and Odessa plate collections. In consequence of us analysis of these observations and of the AFOEV data, the two types of long-time variability were distinguished: (1) outbursts with characteristic time $\sim 212^d$; (2) transitions between the high and low luminosity states with a cycle length $\sim 250^d$; (3) variations with amplitude about 2^m and smaller and at different time scales.

Key words: Stars: Cataclysmic; Individual: V Sge

Table 1. UBV-magnitudes of comparison stars.

stars	V	B	U
x	8.680	8.870	9.040
z	9.192	10.641	11.698
a	10.696	11.001	11.301
b	10.439	11.531	-
c	10.937	11.824	-
d	11.021	12.238	-
e	11.699	12.797	13.498
f	12.597	13.156	13.185
g	12.752	13.465	-

Introduction

V Sge is one of the most attracting cataclysmic variables. Being very bright ($8^m.6 - 13^m.9$ Kholopov et al., 1987), it was discovered at the beginning of the century. The estimate of the orbital period $P = 0^d.514195$ (Herbig et al., 1965) was slightly corrected ($P = 0^d.514198$) by Koch et al. (1986) The period variations were found by Smak (1995). In the Catalogue by Aslanov et al. (1989) also mentioned the slow photometric cycle of 550^d and fast coherent (47.7 s) oscillations.

Recent interest to the object is partially connected with observational and theoretical study of the winds from the accretion disks in cataclysmic variables (Vitello and Shlosman 1993, Mauche 1994, Nafar et al. 1992). In 1995 the international campaign for photometric observations of this star was initiated by Hric et al. (1996).

Šimon (1996) distinguishes the following types of the brightness variations:

1) large outburst with an amplitude about 2^m;

2) transitions from the high to the low state and vice versa;

3) small outbursts (about $0^m.7$);

4) year–to–year brightness variations.

We shall use his terminology for uniformity to describe the variability of V Sge.

In this paper we discuss results of photographic photometry and of the visual estimates from the AFOEV database (Schweitzer, 1993). The analysis of the UBV photoelectric observations one may find in Marsakova et al. (1997).

Photographic Observations and their Analysis

V Sge was studied on 277 photonegatives of the Moscow and Odessa plate collections covering the interval JD 2414309–48884. In both cases the emulsion ORWO ZU–21 was used, thus only minor differences between the instrumental systems were achieved. The UBV–magnitudes of the comparison stars were obtained by S.Yu. Shugarov (Marsakova et al. 1997), they are listed in the Table 1 and are shown in the finding charts (Fig. 1).

The shape of the phase light curve varies depending on the luminosity state. In Fig. 2 (up) the crosses correspond to the "low" state with more deep minima; the circles – to the "high" state where the orbital variability is not pronounced in photographic observations.

We have suggested the mathematical model of orbital variability to reduce its influence on the long–period variability (cf. Marsakova 1998) where the amplitude of the phase light curve changes lineally from that of the trigonometric polynomial fit of the low state light curve (solid line) to zero at the magnitude 10^m.

The results of the periodogram analysis (using the

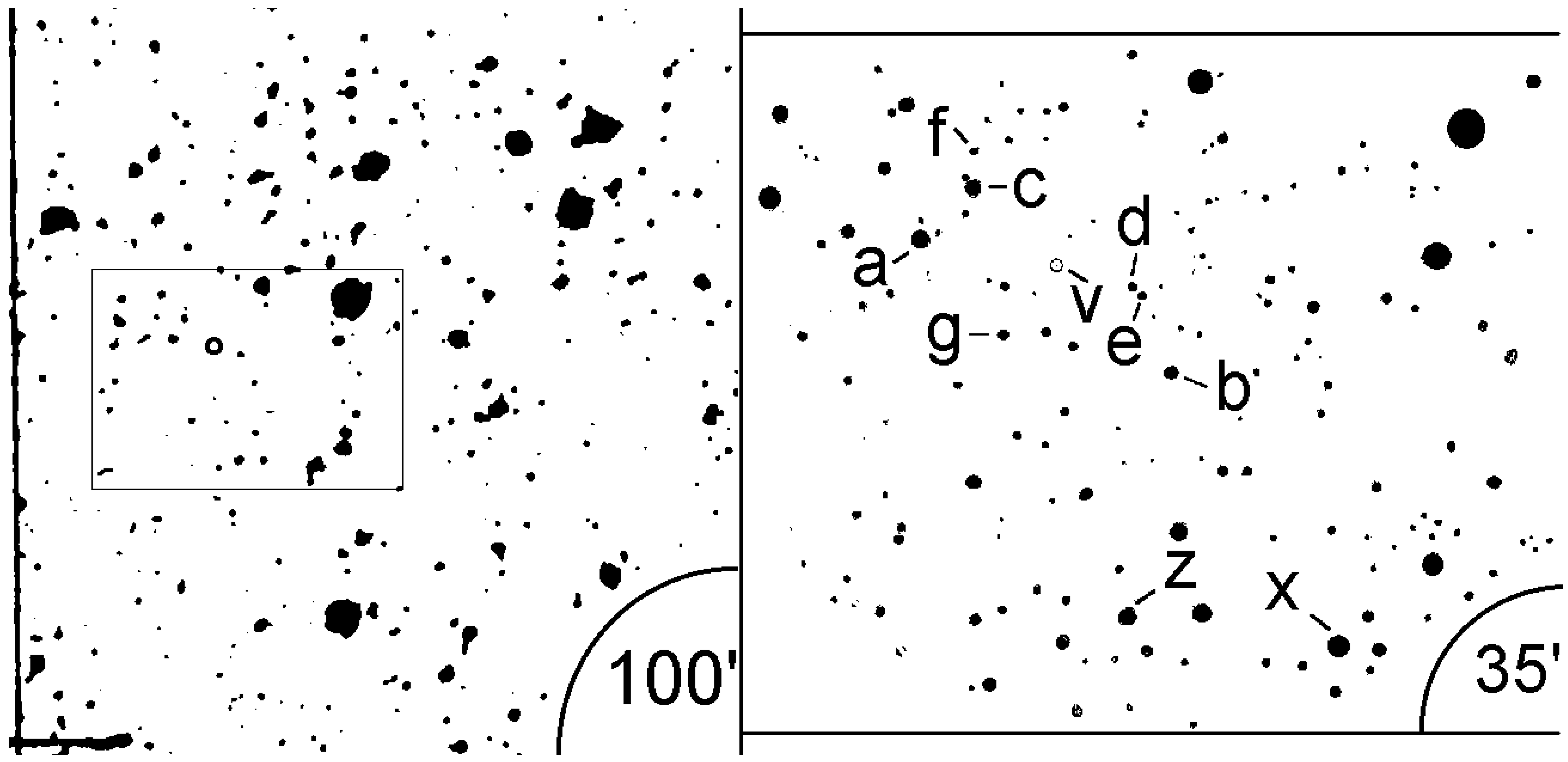

Figure 1. Finding charts for V Sge

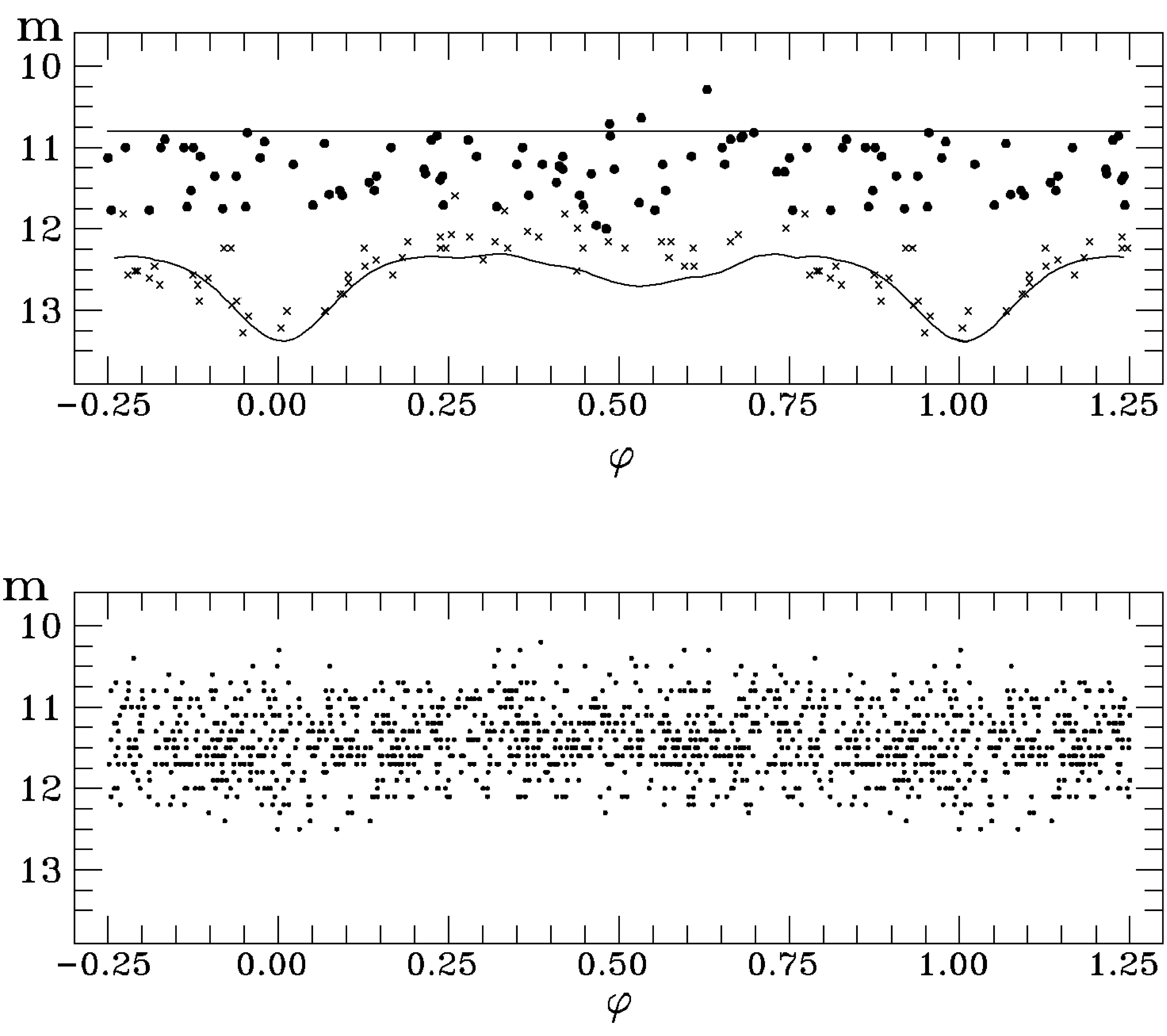

Figure 2. Phase light curve corresponding to the elements by Smak (1995) at the interval JD 2445700-47600 for the photographic observations (up) in "high" (circles) and "low" (crosses) states with a trigonometric polynomial fit of 4-th order (solid line) and for the AFOEV observations (bottom).

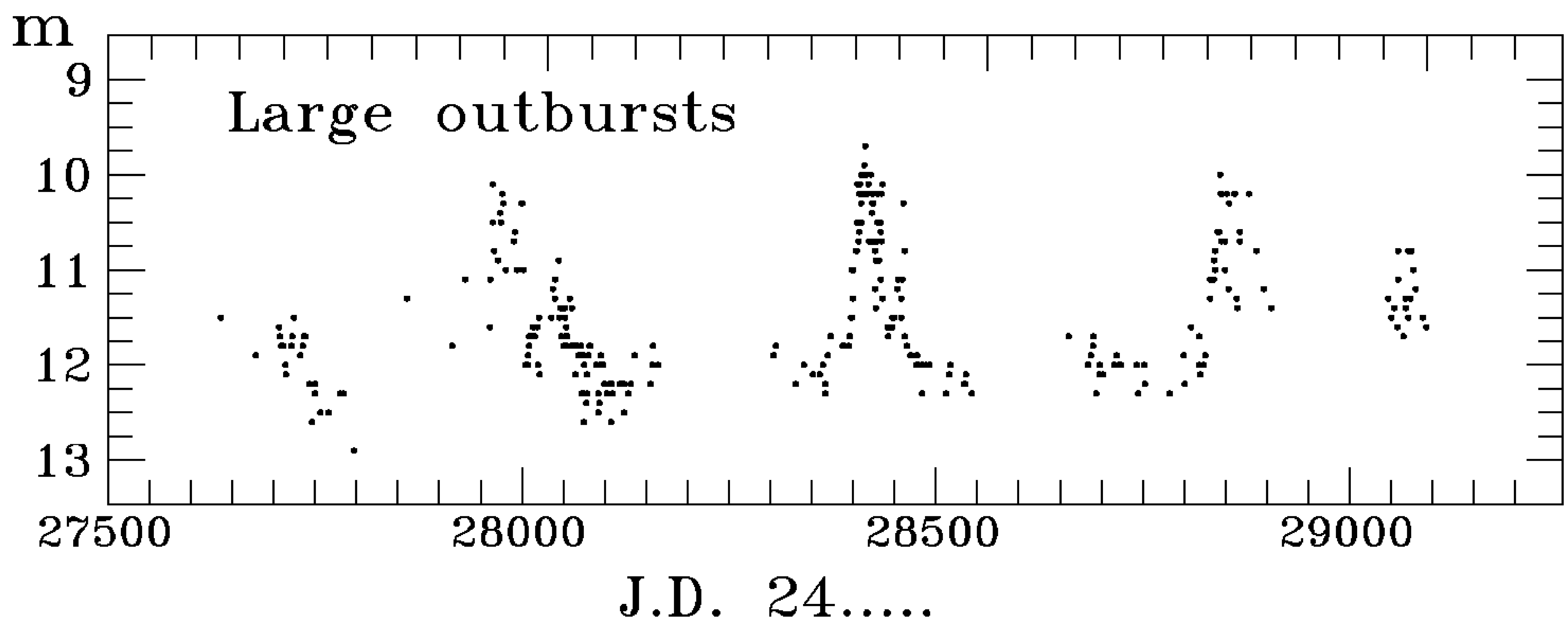

Figure 3. Part of the light curve from the AFOEV database at the intervals of large outbursts.

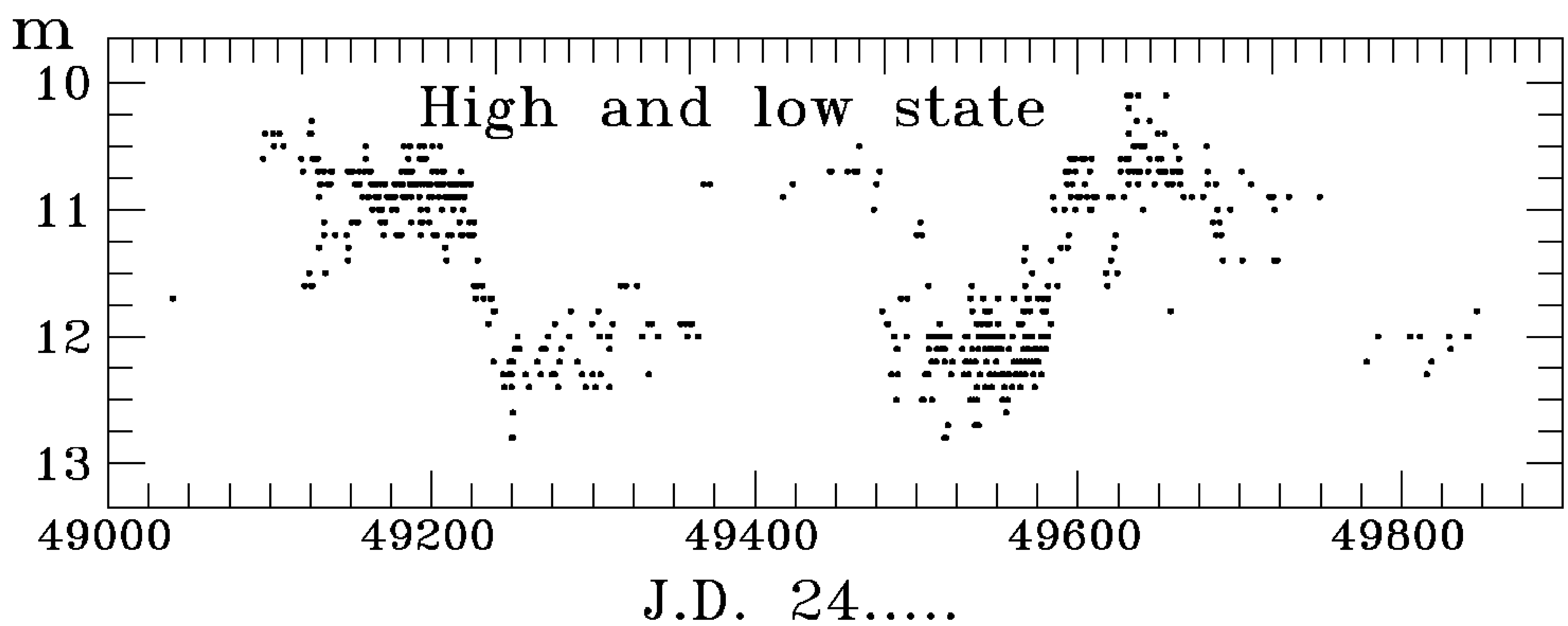

Figure 4. Part of the light curve from the AFOEV database at the intervals with the "high–to–low state" transitions.

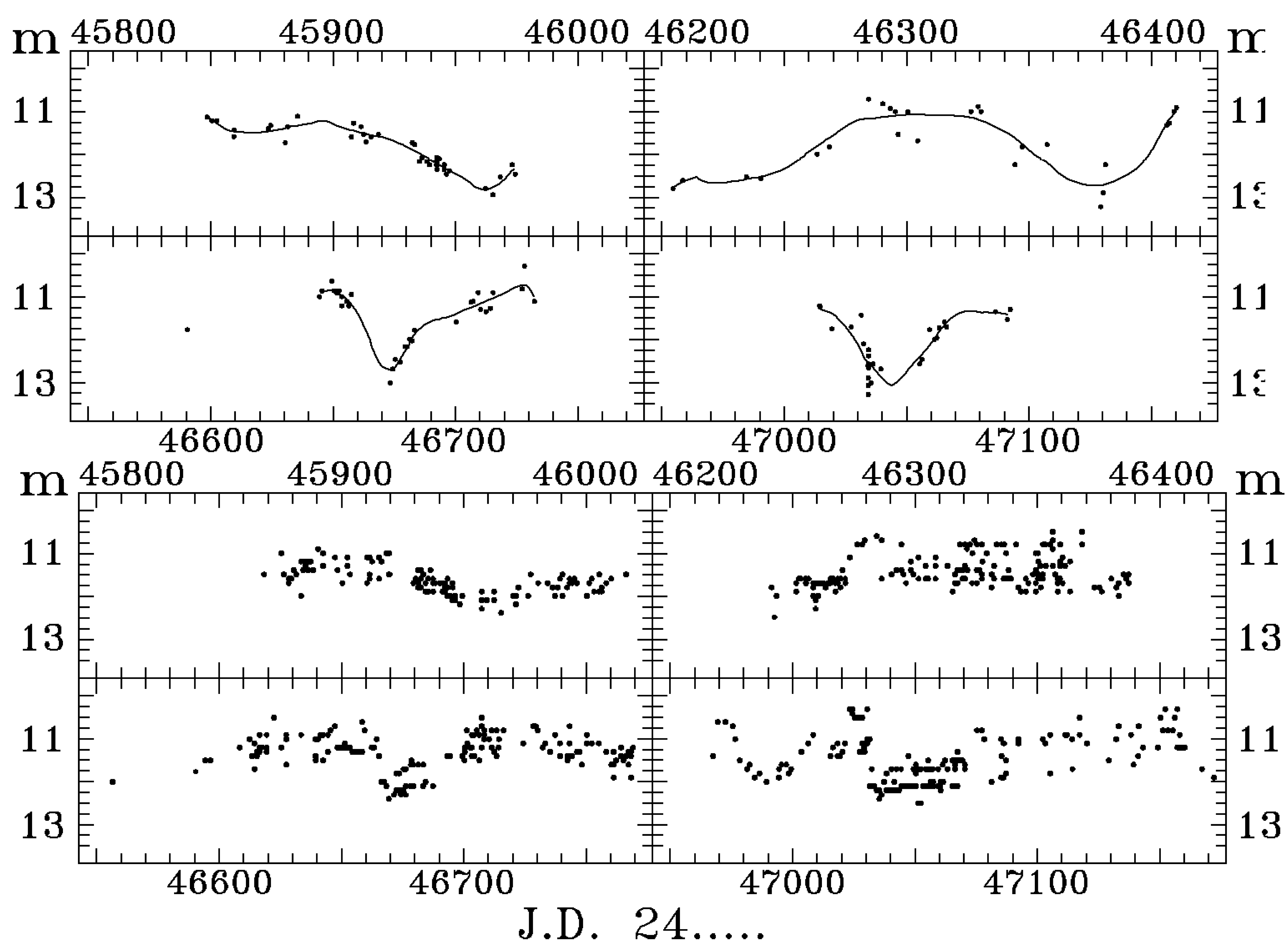

Figure 4. Part of the light curve for the photographic observations fitted by running parabolae (up) and for the AFOEV observations (bottom) in the interval JD 2445700-47600 (the type (3) of changes with smallest cycle length).

Table 2. Results of periodogram analysis of photographic observations. See the text for explanations.

JD 24.....	P	$S(f)$	L_p	P_{O-C}
initial				
44300-48090	914	0.19	9.3	36.7
39600-48890	73.0	0.21	9.9	211*
45850-48890	923	0.25	10.4	36.7
45850-47100	60.6	0.45	14.2	208*
reduced				
44300-48090	215*	0.20	10.4	40.8
39600-48890	896	0.23	10.9	91.2
45850-48890	929	0.28	12.2	87.7
45850-47100	60.6	0.46	14.5	210*

Table 3. Results of the periodogram analysis of the AFOEV observations.

interval JD 24.....	P	$S(f)$	$-\lg Pr$
25700–29000	212	0.46	40.06
49000–50000	243	0.71	93.27
29000–31500	1394	0.11	2.23
39300–42500	356	0.18	21.01
42800–44300	605	0.09	5.85
44600–45700	463	0.13	14.47
45700–47600	74.0	0.11	21.29
47600–49000	464	0.11	15.13

program FOUR-0 by Andronov (1994)) in some observational intervals for both cases (initial observations and the ones with reduced orbital variability) are shown in Table 2. There P is the best fit period; $S(f) = \sigma_C^2/\sigma_O^2$ is the maximum value of the periodogram, 10^{-L_p} is the "false alarm probability", i.e the probability to obtain a peak of a given height at one of the "independent frequencies", if the data are pure white noise (cf. Terebizh 1992, Andronov 1994,1996); P_{O-C} is the best fit period computed for the residual of the observations "O" from the best sine fit "C" to the original data; the values of period corresponding to a cycle length close $212^{\rm d}$ are marked by "*".

Results of the Analysis of the AFOEV Data

The AFOEV visual estimates also were used for the period search. The variance of observations (related to differences of individual system of many observers) was so large that the orbital variability can't be extracted (see Fig 2.). The three types of variability were distinguished from the long–time light curve:

1) large outbursts with a characteristic time ~ 212 days and a range $\sim 10-13^{\rm m}$,

2) transitions between the "high" ($\sim 10\overset{\rm m}{.}5$) and "low" ($\sim 12\overset{\rm m}{.}5$) state with a cycle length $\sim 250^{\rm d}$,

3) variations in a range about $10\overset{\rm m}{.}5 - 12\overset{\rm m}{.}5$, the amplitude and their characteristic times are different in different time intervals.

All types of variations are shown in Fig. 3,4. In the interval JD 244570-47600 the characteristic time is equal to about $74^{\rm d}$ (corresponding to 61 days in the same interval derived from the photographic observations). These variations were approximated by a running parabola fit (Andronov, 1997) with a filter half-width $50^{\rm d}$ (JD 2446200-46420) and $25^{\rm d}$ (the rest) (see Fig 4). In the intervals JD 2444600–45700 and 2447600–49000 it is equal $464^{\rm d}$($\approx 930^{\rm d}/2$ in photographic data). The results of the periodogram analysis are listed in detail in Table 3.

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