COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 6083

Konkoly Observatory
Budapest
25 November 2013

HU ISSN 0374 – 0676

HISTORIC OUTBURSTS OF MASTER OT J023406.06+384142.4

NESCI, R.

INAF/IAPS, via Fosso del Cavaliere 100, 00133, Roma, Italy, e-mail: roberto.nesci@iaps.inaf.it

The robotic MASTER network reported on 2013-07-20 an optical transient at J023406.1 +384142 (Shurpakov et al. 2013). The source was detected at unfiltered magnitude 15.6, and a previous bright state at 17.5 mag was detected by NEAT on 2002-11-25. The authors suggested that the source is likely a cataclysmic variable of the SU UMa type from the 5 mag outburst amplitude. This kind of stars has frequent "normal" outbursts (about 3 mag amplitude) with rare superoutbursts (4 mag amplitude or more). I looked for historic outbursts of this star in the Schmidt plate collection of the Asiago Observatory, finding a large number of plates taken for the Asiago Supernova patrol. The logbook of the Asiago Plate Archive is downloadable from the Observatory web page.

Overall I checked 565 plates of the 50/40/100 cm Schmidt telescope (S50) and 86 plates of the 92/67/215 cm Schmidt telescope (S90), covering about 24 years. These exposures were taken on plates with blue sensitive emulsions: 103aO (351), TRI-X (188), PANCRO-ROYAL (24), mostly without filter in the case of the S50, 103aO with GG13 (blue) filter for the S90. In many cases two plates were taken each night with the S50 to compare different emulsions: the overall number of nights with useful observations is 384.

Stellar magnitudes were estimated by eye with a binocular microscope used for comparison a sequence of nearby stars taken from the GSC 2.3.2 catalog (Lasker et al. 2008), ranging from $B = 15\overset{m}{.}6$ to $19\overset{m}{.}5$. A histogram of the limiting magnitudes is shown in Fig. 1: for the S50 it was generally between $B = 17\overset{m}{.}0$ and $18\overset{m}{.}3$, while for the S90 it was nearly always better than $18\overset{m}{.}0$. A few plates were substantially less deep, due to weather conditions, moonlight or short exposure time. The star was clearly visible on 28 plates of the small Schmidt, grouped around 7 dates, and possibly detected on other 8 plates. It was also well detected on 3 plates of the S90, confirming detections of the S50.

In Table 1, for each brightening episode, the following data are reported: 1) the outburst date; 2) the corresponding MJD; 3) the peak magnitude; 4) the number of plates with the star detected; 5) the number of days the star was visible; 6) the number of days between the last plate without detection and the first detection; 7) the number of days between the last detection and the first plate without detection; 8) the time difference from the previous outburst; 9) a tentative recurrence time scale with an integer number of outbursts between the observed ones; 10) the telescope(s) used.

The maximum recorded brightness of the star was about 16 mag, similar to the MASTER outburst detection, with other high states at 16.5 or 17 mag. The number of plates with limiting magnitude $\leq$16 is 69, and $\leq$ 17 is 160. Besides that reason, several

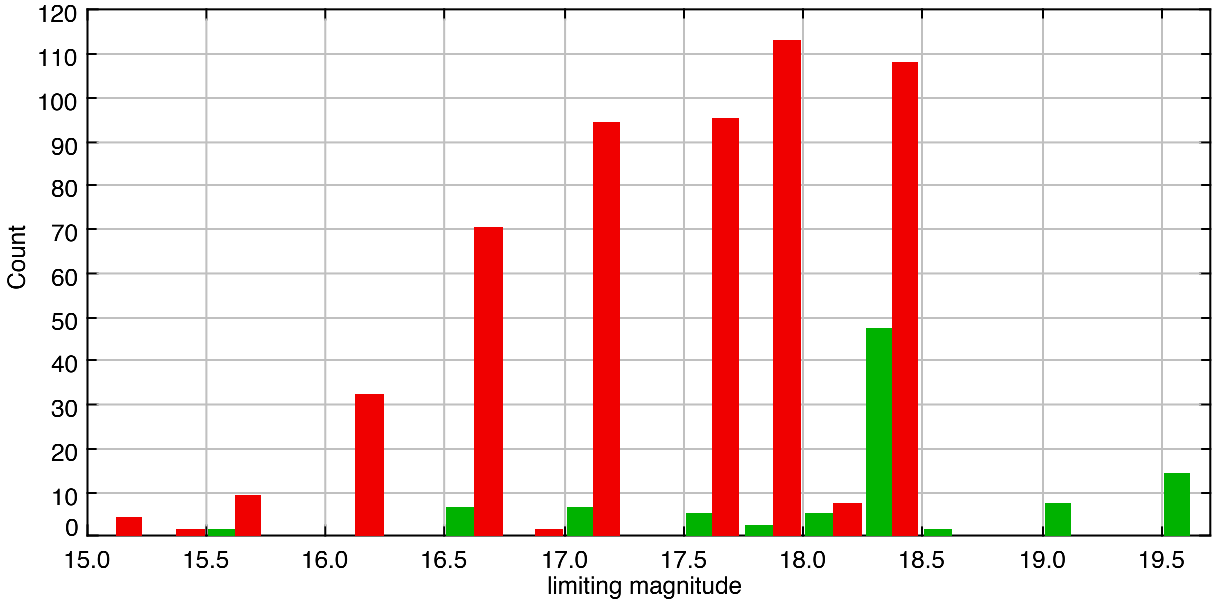

Figure 1. Histogram of the limiting magnitude of the Asiago plates. Green columns denote the S90 plates, while red columns show the S50 ones. Bins are 0.25 mag wide.

high states may have escaped detection due to time sampling, which was unavoidably not strictly regular, nor very dense. Following is a short description of the detected outbursts.

Table 1. Detected outbursts of J023406.1+384142.

1 YYYY-MM-DD	2 MJD	3 mag	4 np	5 days	6 before	7 after	8 delta	9 $N \times T$	10 comm
1961-27-12	37660.87	16.0	5	13	2	15	—	—	S50
1969-10-09	40503.99	16.0	9	8	1332	15	2838	9 × 315	S50
1971-02-25	41007.79	16.0	4	1	6	184	501	2 × 250	S50
1974-10-17	42337.01	17.0	5	6	242	4	1330	4 × 332	S50
1982-12-09	45312.88	16.5	3	2	27	52	2975	9 × 330	S90 and S50
1984-10-24	45997.01	16.5	3	1	28	7	683	2 × 341	S90 and S50
1985-09-10	46318.94	16.5	2	1	22	12	321	1 × 321	S50

- The first well recorded outburst was that on MJD 37660: the star was below 18.3 mag two days before, appeared at 16.0 mag and remained at this level for 10 days, began to drop at 16.5 mag two days after and was below 18 mag after further 15 days. The relevant light curve is shown in Fig. 2.
- The second well documented outburst was that on MJD 40503: the star appeared already at 16 mag, was bright for 8 days and was not detectable 15 days later.
- The third outburst was on MJD 41007: the star appeared at mag 16 in four plates taken the same day. The next plate was taken 6 months later, so we have no information on the outburst duration.
- The fourth outburst was definitely fainter, 17 mag, on MJD 42337. The star was possibly detected at the plate limit (18.3 mag) four days before, it was seen in two

pairs of plates on MJD 42337 and 42338 and was already below the plate limit (17.5 mag) four days after.

- The fifth outburst was caught by the small Schmidt at 17.5 mag on MJD 45312; it was confirmed two days later by the large Schmidt at 16.5 mag.
- The sixth outburst was on MJD 45997, recorded on two plates of the small Schmidt (17.0 mag) and one plate (16.5 mag) of the large Schmidt.
- The last outburst on MJD 46318 was recorded on two consecutive plates at 16.5 mag; the star was already below 18.3 mag in both Schmidt telescopes 12 days after.

From the best sampled outbursts we estimate that the star undergoes large brightenings with a duration of about 10 days. This is a typical time scale for several cataclysmic variables.

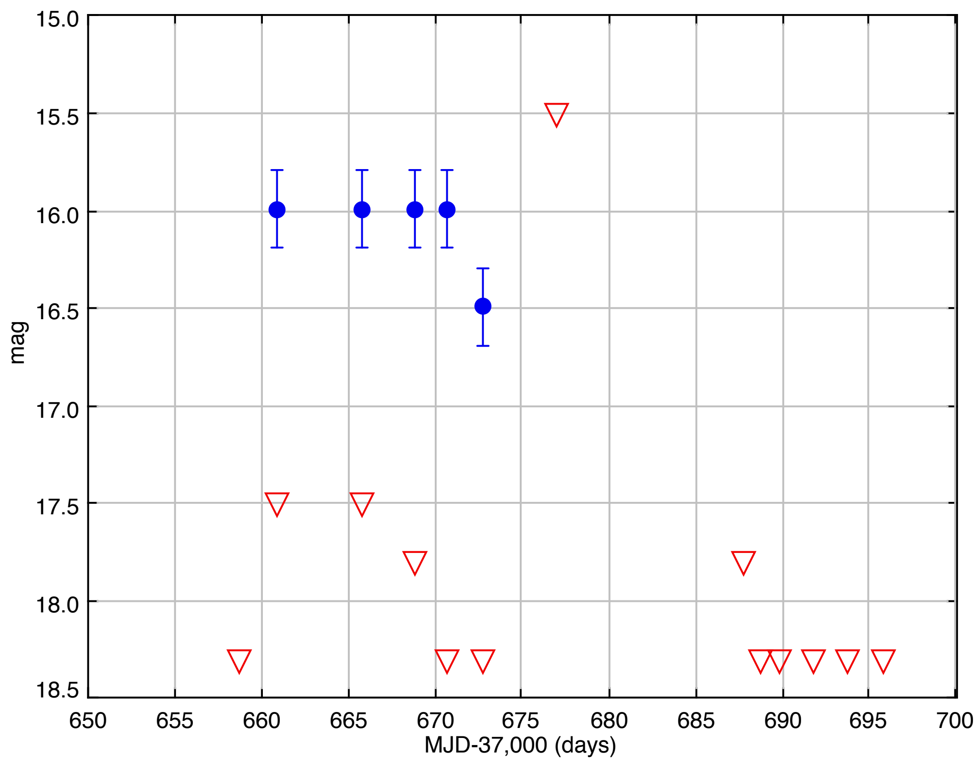

Figure 2. Light curve of the outburst on MJD 37660. Blue points are detections, red triangles the upper limit of the corresponding plate.

Trying to determine a recurrence time scale for the large outbursts is not easy due to the sparse sampling and to the very fact that these superoutbursts are not strictly periodic: an estimate can be obtained looking for the largest possible integer number of days T between two consecutive outbursts in Table 1: the results are listed in column 9 of Table 1, where the time interval T and the number of intervals N are reported. The results are fairly consistent, suggesting a recurrence time scale of the order of 300 days, which is nearly double of the typical superoutburst interval of SU UMa itself. I have checked if, assuming the recurrence time was true, the missed outbursts were lost for lack of plates at the proper date: this assumption often proved to be valid, but in some cases the outburst should be detected if it happened at the predicted date. However, given the very short duration of the outbursts (about 10 days or less), the large gaps in the observations, and the large uncertainty of the outburst epochs due to the lack of a strict period in this kind of stars, this test cannot be conclusive.

Shurpakov et al. (2013) quoted also a previous bright state detected by the NEAT program on 2002-11-15 (MJD 52594). As a further check we computed the recurrence time scale using the last Asiago outburst, the NEAT outburst and the MASTER (MJD 56494) one in the same way. The results are: 20×330 d (Asiago-NEAT) and 12×325 d (NEAT-MASTER), therefore compatible with the recurrence time from the historical Asiago data.

All these finding support the classification of the star as a SU UMa cataclysmic variable.

From a statistical point of view, there are 384 dates with observations in the Asiago archive, spanning about 24 years (11061 days): assuming a high state of 10 days and an average recurrence of 320 days, one should expect about 34 outbursts and that the star was detectable on 340 days. Given our temporal fractional coverage of 0.0347 (384/11061) one should expect detection on 12 days, while we found 29. The "order of magnitude" agreement may be regarded as satisfactory, given the large uncertainties in the assumed recurrence time and outburst duration. A recurrence of 160 days instead of 320 would produce a very good statistical agreement and cannot be ruled out by the present data set.

The peak magnitude difference between an outburst and a superoutburst is about 1 mag in SU UMa stars: if superoutbursts in our star reach 16.0 mag then a brightening at 17.0 mag (like that on MJD 42337) might be considered as a normal outburst. The photometric accuracy of these plates is however rather low, especially near the plate limit, as is often the case for our star: due to the short (1 m) focal length of the telescope, the apparent diameter of a faint star is very similar to the emulsion grain size, and plate noise may be misinterpreted as a detection if located at the expected star position. Our estimate of 0.2 mag uncertainty is therefore rather optimistic in these cases.

The large majority of our plates are from the S50 telescope, with a limiting magnitude mostly in the magnitude range 17.0-17.5 (see Fig. 1): normal outbursts are therefore unlikely to have been recorded.

Further monitoring of this star may be easily performed even by amateurs with a small telescope and a CCD camera, for its position in the northern sky allows a good coverage during the year.

Acknowledgements: The author thanks the Asiago Observatory for access to the plate archive to perform this research.

References:

Asiago Plate Archive:
http://www.oapd.inaf.it/index.php/en/telescopes-and-instrumentations/archive-and-publication.html

Lasker B., Lattanzi M.G., McLean B.J. et al., 2008, *AJ*, **136**, 735, GSC 2.3.2 CDS catalog I/271

NEAT - SkyMorph GSFC: http://skyview.gsfc.nasa.gov/skymorph/skymorph.html

Shurpakov S., Denisenko, D., Lipunov V., et al., 2013, *ATel*, **5217**