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Photometry of Transient 2023lmj, an UGSU Cataclysmic Variable Star

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I present a photometric study of the new UGSU cataclysmic variable star discovered as the transient 2023lmj. 160 V-band observations of the object were obtained on JD 2460120–2460142. The period of superhumps is found to be $0^{\rm d}.06033$. An overall light curve and average superhump profile are shown.

1 Introduction

The optical transient 2023lmj was detected on JD 2460119 (Sokolovsky et al., 2023). Several days later, Zhao & Gao (2023) obtained the spectrum of the transient and classified it as a cataclysmic variable star.

On the next night after discovering, I started my observations at the Caucasian Mountain Observatory (CMO) of M.V. Lomonosov Moscow State University (see Shatsky et al., 2020) using the 0.25-m remote-controlled Ritchey–Chretien telescope, equipped with a SBIG STXL-6303e CCD camera and a V filter. A total of 978 images of the field with 600-second exposures were obtained on JD 2460120–2460257, but the star is visible only on 163 images, obtained on JD 2460120–2460142.

2 Primary reduction and magnitude calibration

For basic reductions for dark current, flat fields, and bias, we used IRAF routines and proprietary software TheSkyX$^{\rm TM}$ by Software Bisque Inc. For calibration, each observing night we obtained 16 bias frames, 16 dark frames, 16 flat fields, plus 16 dark frames corresponding to flat fields.

For photometry of the cataclysmic variable star, we applied VaST software by Sokolovsky & Lebedev (2018). All times in this paper are expressed in terrestrial time in accordance with IAU recommendations (resolution B1 XXIII IAU GA), with heliocentric corrections applied.

For plotting light curves, we used our own routines, written in Python 3 programming language using NumPy (Harris et al., 2020) and Matplotlib (Hunter, 2007) libraries.

For magnitude calibration in V band, we use data of the GAIA DR3 catalogue. We restrict ourselves to single, relatively bright stars, with no saturation of pixels for our CCD camera, no close neighbors, and demonstrating no brightness variations during the time interval of our observations. Detailed information about our calibration stars is collected in Table 1. Uncertainties in the σ_V column were derives from our photometry; GAIA G,

G_{BP}, and G_{RP} magnitudes were drawn from the corresponding catalog. Magnitudes in the "Calc. V" column were obtained using the equation:

$$\text{Calc. } V = \text{Gaia } G - [-0.02704 + 0.01424 \times (G_{BP} - G_{RP}) - 0.2156 \times (G_{BP} - G_{RP})^2 + 0.01426 \times (G_{BP} - G_{RP})^3], \quad (1)$$

based on Table 5.9 of the Gaia Data Release 3, Documentation release 1.2 (https://gea.esac.esa.int/archive/documentation/GDR3/).

Table 1. Magnitudes of calibration stars

GSC name	σ_V	GAIA			Calc. V
		G	G_{BP}	G_{RP}	
01051-01179	0.005	12.7355	12.9894	12.3245	12.8442
01051-01491	0.004	12.0755	12.8689	11.2027	12.6114
01585-00306	0.005	11.9655	12.9243	11.0048	12.6587
01584-00111	0.005	12.2554	12.7376	11.6132	12.5187
01051-01757	0.004	12.1621	12.5855	11.5643	12.3843
01051-00969	0.004	11.8089	12.5785	12.5785	12.3215

3 Results

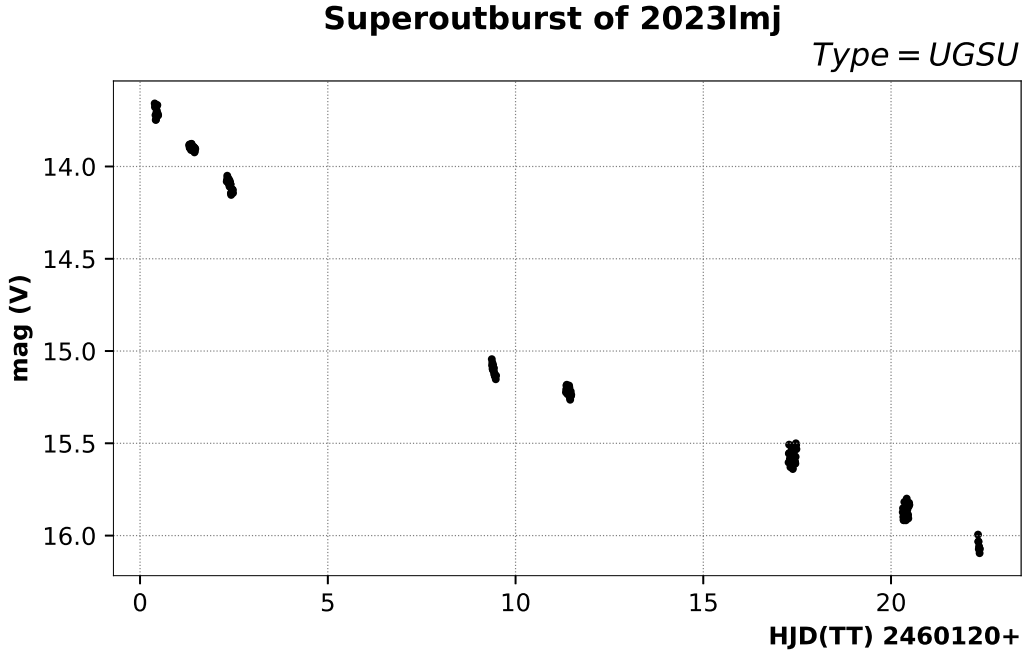

Figure 1. The superoutburst of 2023lmj: overall light curve.

Observations of this star demonstrate rapid variations at a time scale of about $0^{\rm d}.06$ with a peak-to-peak amplitude about $0^{\rm m}.12$ on each observing night and with average level decreasing from $13^{\rm m}.70$ (V) on JD 2460120 to $16^{\rm m}.05$ (V) on JD 2460142. This photometric behavior is typical of cataclysmic variable stars of the UGSU subtype. Note that superhumps were already observed on the first night after the superoutburst, JD 2460120 (see

the top light curve in Fig. 2). Unfortunately, because of the weather conditions, observations were interrupted after JD 2460142 and resumed on JD 2460159, when nothing brighter than $19\overset{m}{.}3$ (V) was visible at the position of the star.

Using Peranso software by Paunzen and Vanmunster (2016), we performed a period analysis with discrete Fourier transform, very suitable for analyzing sine-shaped superhump profiles of cataclysmic variable stars. The best period of superhumps is $0\overset{d}{.}06033$, typical of UGSU variable stars. The average superhump profile with the following light elements:

$$\text{Max HJD(TT)} = 2460120.455 + 0\overset{d}{.}06033 \times E$$

in filter V is presented in Fig. 3.

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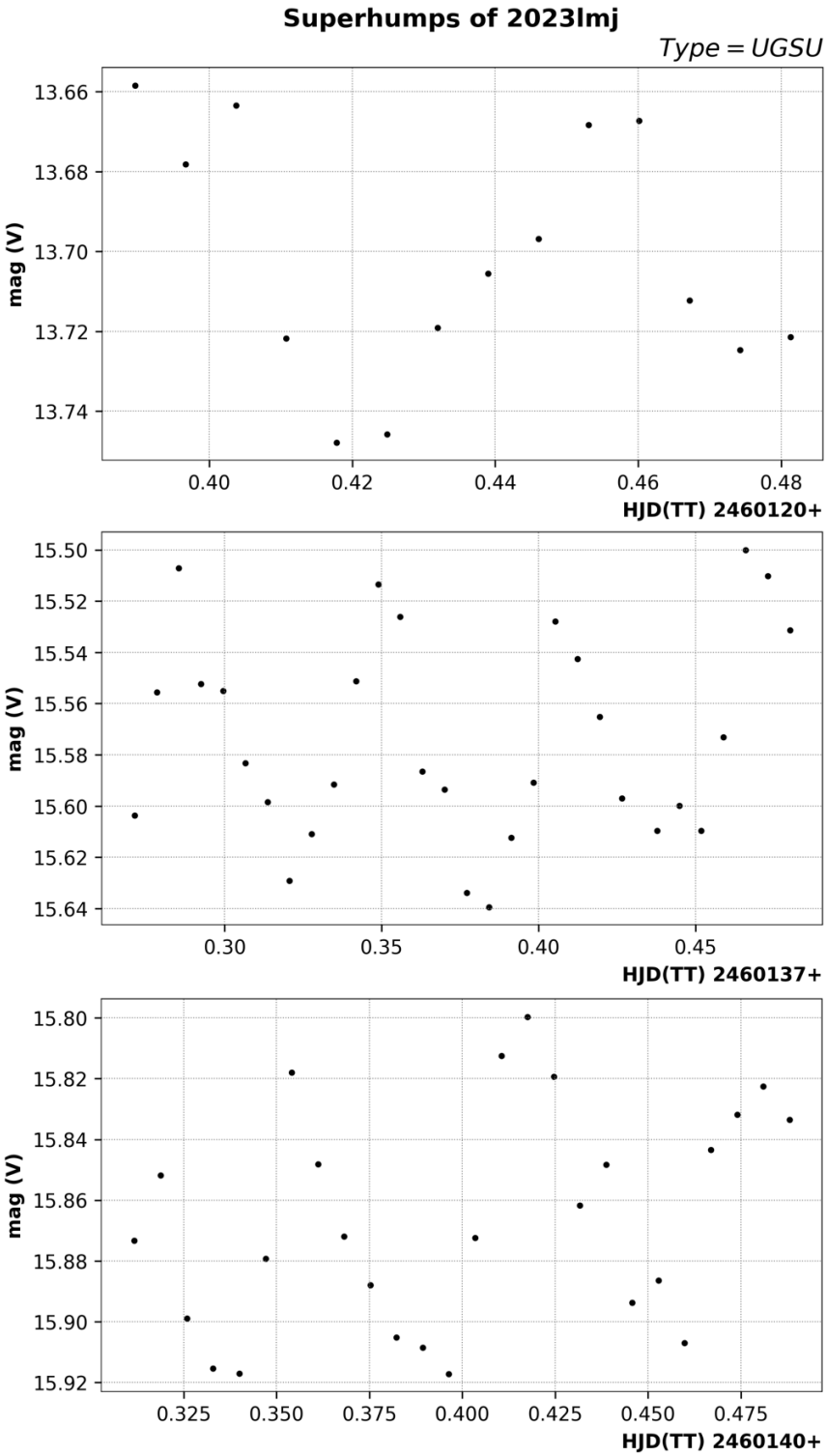

Figure 2. Superhumps of 2023lmj at different stages of the superoutburst.

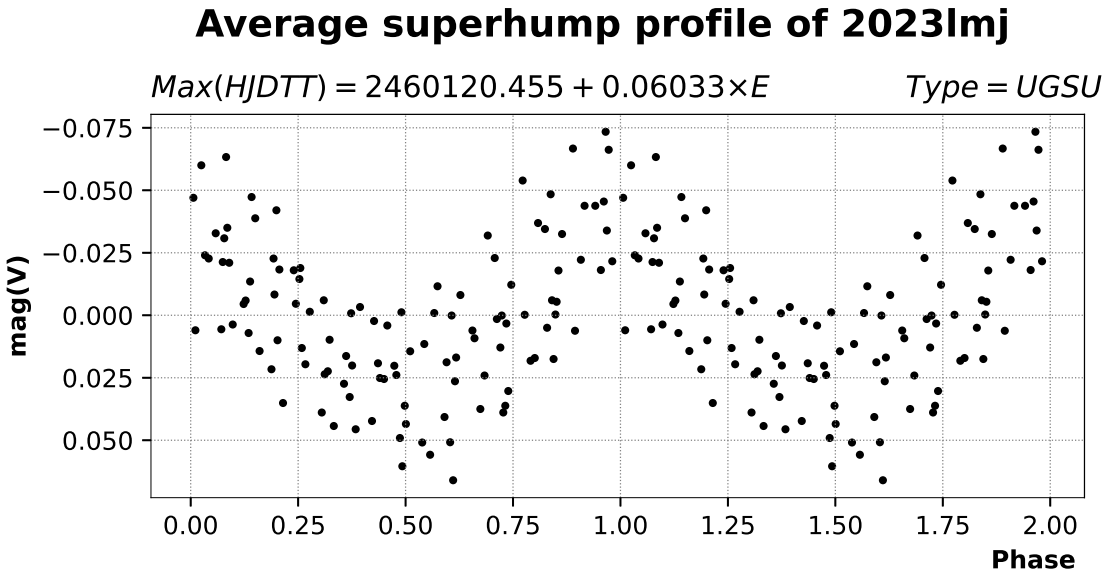

Figure 3. The average superhump profile of 2023lmj.