BV photometry of the cataclysmic variable LY UMa

L. Dankova[1], D. Marchev[2], S. Peneva[1], R. Zamanov[1]

[1]Institute of Astronomy and National Astronomical Observatory, Bulgarian Academy of Sciences, Tsarigradsko Shose 72, BG-1784 Sofia, Bulgaria

[2]Department of Physics and Astronomy, Shumen University "Episkop Konstantin Preslavski", 115 Universitetska Str., 9700 Shumen, Bulgaria

e-mails: speneva@nao-rozhen.org, rzamanov@nao-rozhen.org

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Abstract. We performed B- and V-band photometry of the probable dwarf nova LY UMa. We find that it has apparent magnitude $V = 15.26 \pm 0.03$ on 2024-04-14, $V = 15.43 \pm 0.02$ on 2025-04-28, and $V = 15.57 \pm 0.02$ on 2025-06-02. Using the Gaia distance $d = 310$ pc, we find that the lower values correspond to absolute V band magnitude $M_V \approx 7.94 - -8.10$ and indicate that the mass donor of LY UMa is a K7-K8V star with $M_V \approx 8.0 - -8.5$. Our B-band measurements show slightly bluer $B - V$ index of LY UMa than that of its donor, consistent with its nature as a cataclysmic variable.
Close to LY UMa is the active galactic nucleus candidate Mrk 153, for which we estimate $V = 14.81 \pm 0.03$.

Key words: stars: dwarf novae – novae, cataclysmic variables – stars: individual: LY UMa

1 Introduction

Cataclysmic variable stars (CVs) are so named because they irregularly increase in brightness (sometimes by a factor of 10–100 or even larger), before dropping back to a quiescent state. CVs consist of two components: a white dwarf and a mass donor star. They are divided into several sub-types – nova-like variables, dwarf novae, magnetic, AM CVn binaries, classical novae, recurrent novae, etc. (Warner 1995).

CVs are a result of the evolution of pairs of main-sequence stars. The white dwarf components of CVs were once the cores of giant stars much larger than present-day CVs. The standard theory for the evolution of binary stars requires that the system passes through a phase during which both stars orbit within a common envelope (a result of the expansion of the giant star). As the stars orbit, they transfer angular momentum to the envelope. The envelope is ejected and leaves a binary star with short orbital period (a few hours), e.g., Marsh (2000), Solheim (2010), and references therein.

LY UMa (CW 1045+525) is a variable star in the constellation Ursa Major. It is an emission-line binary with a strong late-K contribution and no reported outbursts. The orbital period is $P_{orb} = 0.2712788$ days, which is 6.51 hours (Tappert et al. 2001, Thorstensen et al. 2017).

Here we report B- and V-band photometry of LY UMa. The V-band magnitude of Mrk 153, located close to LY UMa, was also estimated.

2 Observations and data processing

The observations were secured with the 2.0 m and the 50/70 cm Schmidt telescopes of the Rozhen National Astronomical Observatory, Bulgaria (Golev et

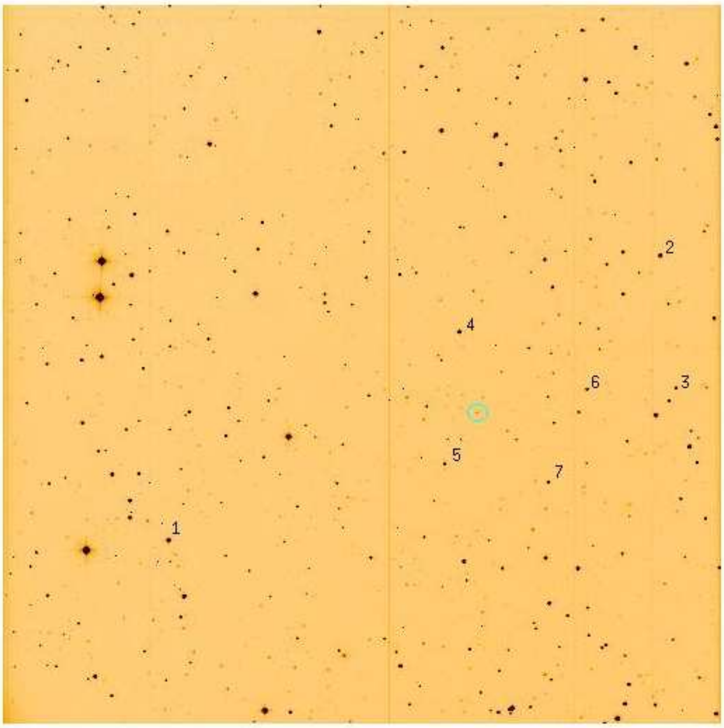

Fig. 1. V-band image of the field around LY UMa, obtained with the 50/70 cm Schmidt telescope of NAO Rozhen on 2025-04-28T21:45, exposure time 60 s. The field of view is 61×61 arcmin. LY UMa is marked with a circle. The comparison stars are marked with numbers from 1 to 7. Their coordinates and magnitudes can be found in Table 1.

al. 1982; Tsvetkov et al. 1987) and with the new 60 cm Ritchey-Chrétien telescope of the Shumen University Astronomical Center (Marchev et al. 2025). The telescopes are equipped with CCD cameras: Andor iKON-L (2.0 m telescope), FLI PL 16803 (50/70 cm Schmidt telescope), and SBIG Aluma4040 (60 cm Shumen telescope).

LY UMa has coordinates J2000 10:48:18.0 +52:18:29. The object is located in a direction (Galactic coordinates ep=J2000: 156.88544 +55.9249) with negligible interstellar dust, and several quasars and galaxies can be seen in the field. The brightest among them is Mrk 153.

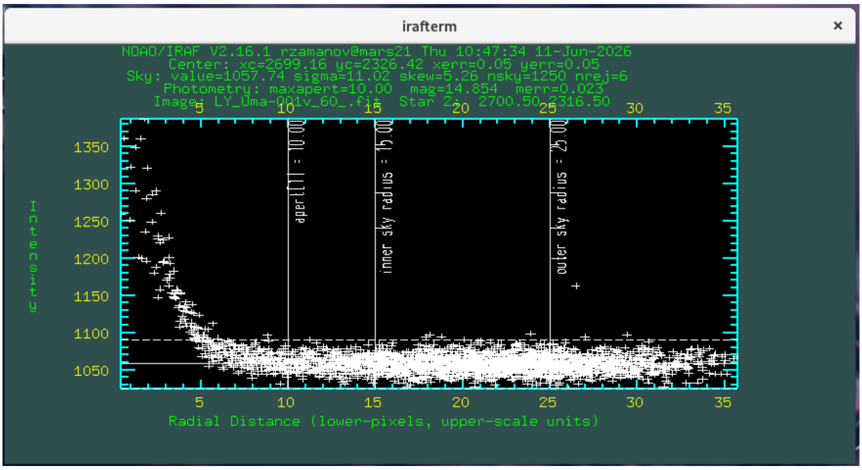

Fig. 2. Example of photometry with *qphot* in IRAF.

The field of view of the 50/70 cm Schmidt telescope is 61×61 arcmin, with CCD frame 4096×4096 pixels; this gives 0.9 arcsec/pixel. For the data processing we used IRAF (Tody 1993). Typical level of the bias of our CCD frames is 988 ± 8 counts. Averaging 8 bias images, we achieve 988 ± 4 counts. Here we give some of the critical parameters used in *qphot* of IRAF:

cbox = 30.	The centering box width in pixels
annulus = 15.	The inner radius of sky annulus in pixels
dannulus= 10.	The width of the sky annulus in pixels
aperture= 10	The list of photometry apertures
(zmag = 25.)	The zero point of the magnitude scale
(interac= yes)	Interactive mode ?
(radplot= yes)	Plot the radial profiles in interactive mode ?

Since we use several comparison stars in the field, the zero-point of the magnitude scale was set to 25 by default. The apertures used are 7 to 10 pixels (corresponding to 6–9 arcsec), the inner radius of sky annulus is usually set to 1.5 apertures, the width of the sky annulus is equal to the aperture, the centering box width is 3–4 apertures. An example of the photometry with

IRAF is given in Fig. 2. The figure shows that at exposure time of 60 s, the sky brightness is about 1060 counts, which is an increase of only about 70 counts compared to the bias level.

3 Results

As a first step, we identified a few stars in the field (see Fig.1) that can be used as comparison stars:

Table 1. Coordinates and magnitudes of the comparison stars around LY UMa.

No.	object	RA	Declination	V Tycho-2	V Gaia	B Gaia
# 1	HD 233778	10 51 44.4	+52 05 23	9.79	9.853	
# 2	TYC 3823-985-1	10 46 13.9	+52 34 27	10.97	11.030	
# 3	...	10 46 04.4	+52 20 54		12.804	
# 4	TYC 3449-829-1	10 48 29.7	+52 26 48	10.86	10.879	11.500
# 5	...	10 48 39.7	+52 13 17		12.940	13.729
# 6	...	10 47 04.0	+52 20 49		12.754	
# 7	TYC 3449-702-1	10 47 30.5	+52 11 20	12.48	12.337	12.849
# 8	...	10 47 57.6	+52 16 36		15.310	16.200
# 9	...	10 47 51.8	+52 15 43		14.876	15.532

The V-band magnitudes are from Tycho-2 (Høg et al. 2000) and Gaia (Gaia collaboration 2022, 2023) catalogues. The Gaia magnitudes are synthetic photometry taken from VizieR catalog I/360/syntphot. After a few measurements, we decided to use as comparison stars #4, #5, #7, #8, adopting their Gaia magnitudes. The measurements are presented in Table 1.

3.1 LY UMa

For LY UMa SIMBAD gives $V = 14.95$, Gaia gives $V = 15.28$. Kazarovets et al. (2006) reported that the object varies in the range $15.44 > V > 14.95$. Our observations give range:
$15.31 > V > 15.22$ for our run on 13/14 April 2024,
$15.46 > V > 15.40$ for our run on 28 April 2025,
$15.59 > V > 15.56$ for our run on 2 June 2025.
In our runs, the visual brightness of LY UMa is in the range $15.59 > V > 15.22$. Its B-band magnitude is in the range $16.67 > B > 16.17$. On 13/14 April 2024, we estimate average $B = 16.27$, $V = 15.26$, and colour $B - V = 1.01$. On 28 April 2025, we estimate average $B = 16.57$, $V = 15.43$, and colour $B - V = 1.14$. As expected, when the star is brighter, it is bluer.

LY UMa is at a distance $d = 310 \pm 2$ pc (Bailer-Jones et al. 2021). There is no interstellar extinction toward the object[1] (Lallement et al. 2019). Using

[1] https://astro.acri-st.fr/gaia_dev/#extinction

Table 2. V- and B-band photometry of LY UMa with the 2.0 m Rozhen telescope.

Date UT	exp-time [s]	V mag	Date UT	exp-time [s]	B mag
2024-04-13 23:37	60	15.248	2024-04-13 23:39	90	16.311
2024-04-13 23:38	60	15.249	2024-04-13 23:40	90	16.301
2024-04-13 23:39	60	15.244	2024-04-13 23:42	90	16.272
2024-04-13 23:40	60	15.254	2024-04-13 23:43	90	16.261
2024-04-13 23:41	60	15.247	2024-04-13 23:45	90	16.240
2024-04-13 23:42	60	15.254	2024-04-13 23:46	90	16.240
2024-04-13 23:43	60	15.243	2024-04-13 23:48	90	16.216
2024-04-13 23:44	60	15.237	2024-04-13 23:49	90	16.195
2024-04-13 23:45	60	15.245	2024-04-13 23:51	90	16.166
2024-04-13 23:46	60	15.248	2024-04-13 23:52	90	16.229
2024-04-13 23:47	60	15.246	2024-04-13 23:54	90	16.269
2024-04-13 23:48	60	15.246	2024-04-13 23:56	90	16.269
2024-04-13 23:49	60	15.232	2024-04-13 23:57	90	16.235
2024-04-13 23:50	60	15.218	2024-04-13 23:59	90	16.300
2024-04-13 23:51	60	15.221	2024-04-14 00:00	90	16.299
2024-04-13 23:52	60	15.240	2024-04-14 00:02	90	16.252
2024-04-13 23:53	60	15.252	2024-04-14 00:03	90	16.306
2024-04-13 23:54	60	15.249	2024-04-14 00:05	90	16.320
2024-04-13 23:55	60	15.256	2024-04-14 00:06	90	16.308
2024-04-13 23:56	60	15.260	2024-04-14 00:08	90	16.342
2024-04-13 23:57	60	15.251	2024-04-14 00:09	90	16.358
2024-04-13 23:58	60	15.268	2024-04-14 00:11	90	16.277
2024-04-13 23:59	60	15.281		mean	16.271 ± 0.047
2024-04-14 00:00	60	15.270			
2024-04-14 00:01	60	15.280			
2024-04-14 00:02	60	15.270			
2024-04-14 00:03	60	15.288			
2024-04-14 00:04	60	15.300			
2024-04-14 00:06	60	15.289			
2024-04-14 00:07	60	15.294			
2024-04-14 00:08	60	15.307			
2024-04-14 00:09	60	15.303			
2024-04-14 00:10	60	15.303			
2024-04-14 00:11	60	15.312			
2024-04-14 00:12	60	15.311			
	mean	15.263 ± 0.031			

Table 3. *V*-band photometry of LY UMa and Mrk 153 with the 50/70 cm Rozhen (2025-04-28) and 60 cm Shumen telescopes (2025-06-02).

telescope	Date UT	exp-time [s]	LY UMa	Mrk 153
50/70 cm	2025-04-28 21:45	60	15.413	14.847
	2025-04-28 21:48	60	15.438	14.813
	2025-04-28 21:51	60	15.420	14.776
	2025-04-28 21:55	60	15.402	14.821
	2025-04-28 21:58	60	15.461	14.811
		mean	15.427 ± 0.023	14.81 ± 0.03
60 cm	2025-06-02 20:04	120	15.588	
	2025-06-02 20:06	120	15.556	
	2025-06-02 20:08	120	15.556	
		mean	15.567 ± 0.008	

Table 4. *B*-band photometry of LY UMa with the 50/70 cm Rozhen telescope.

Date UT	exp-time [s]	LY UMa *B* mag
2025-04-28 22:28:03	90.0	16.559 ± 0.018
2025-04-28 22:31:02	90.0	16.674 ± 0.021
2025-04-28 22:34:01	90.0	16.553 ± 0.019
2025-04-28 22:37:00	90.0	16.554 ± 0.020
2025-04-28 22:39:59	90.0	16.560 ± 0.026
2025-04-28 22:43:11	90.0	16.446 ± 0.019
2025-04-28 22:46:10	90.0	16.596 ± 0.005
2025-04-28 22:49:09	90.0	16.606 ± 0.015
2025-04-28 22:52:08	90.0	16.504 ± 0.018
2025-04-28 22:55:07	90.0	16.601 ± 0.011
	mean	16.565 ± 0.061

the standard formula

$$M = m - 5\log_{10}(d[\text{pc}]) + 5, \tag{1}$$

we estimate the absolute V-band magnitude of LY UMa during our observations $M_V = 7.94 - 8.10$. The spectral observations of LY UMa demonstrate that it is an emission-line binary with a strong late-K contribution (Tappert et al. 2001). Therefore, we assume that the K star contributes $70\% - 95\%$ in the V-band. In this way, we estimate the absolute V-band magnitude of the K star $M_V = 8.49 - 8.00$.

The "Modern Mean Dwarf Stellar Color and Effective Temperature Sequence" by Pecaut & Mamajek (2013)[2] gives the following absolute V-band magnitudes for K-type main-sequence stars: for K6V $M_V = 7.64$, for K7V $M_V = 8.16$, for K8V $M_V = 8.43$, for K9V $M_V = 8.56$. Our photometric observations indicate that most likely the mass donor of LY UMa is of spectral type K7V. Following Pecaut & Mamajek (2013), a typical K7V star has $M_V = 8.16$, colour $B - V = 1.34$, radius $R = 0.63\ R_\odot$, and mass $M = 0.64\ M_\odot$. As expected, the $B - V$ index of LY UMa ($B - V = 1.01 - 1.14$) is bluer, due to the contribution of the accretion flow to the optical brightness.

3.2 Mrk 153

The active galactic nucleus candidate Mrk 153 (Petrosian et al. 2007) is located at 7 arcmin from our primary target LY UMa. Such objects are potentially variable, and we provide our estimate of its brightness $V = 14.81 \pm 0.03$ on 2025-04-28T21:51. The nucleus of the galaxy is ≈ 0.11 magnitudes fainter.

4 Discussion

Tappert et al. (2001) discussed several scenarios for the nature of LY UMa:

1. nova-like – the nova-like CVs are in a permanent state of high mass transfer;
2. dwarf nova – the dwarf novae are in a lower mass transfer state and demonstrate outbursts due to disc instability;
3. magnetic CV – in which the white dwarf is highly magnetized.

Tappert et al. (2001) found that a dwarf nova classification is the most probable, although it does not completely explain the observed characteristics. If LY UMa is really a dwarf nova, it probably has a long period of accumulation of material in the accretion disc. Our results should be useful for future studies of the binary nature of LY UMa.

5 Conclusions

We performed B- and V-band photometry with the 50/70 cm Rozhen, 2.0 m Rozhen, and 60 cm Shumen telescopes of the cataclysmic variable LY UMa,

[2] We use version 2022.04.16 as given at
`https://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJHK_colors_Teff.txt`

and find that its brightness is in the range $V = 15.59 - 15.23$ and colour $B-V = 1.14 - 1.01$. Using the Gaia distance we estimate absolute V-band magnitude of LY UMa $7.94 \leq M_V \leq 8.10$. For the mass donor we find spectral type K7-K8V and absolute V-band magnitude $8.0 \leq M_V \leq 8.5$. For the active galactic nucleus Mrk 153, we observed an apparent magnitude of $V = 14.81 \pm 0.03$.

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