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UBVR observations of the symbiotic star ZZ CMi

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Abstract: *This study is based on photometric observations of ZZ CMi during the last observational season (2024/2025). Other than looking for flickering we were interested in following the variability of brightness in the same period. In the presented multicolor photometry, we find variability throughout each night — pronounced flickering in the U band. The amplitude of the flickering is about 0.22−0.48 mag in the U band. In the B band, the variability is lower, with an amplitude ≤0.05 mag. The work shows multiple convenient standard stars around the symbiotic star ZZ CMi.*

Keywords: Variable stars, Symbiotic stars, ZZ CMi

Introduction

The symbiotic star ZZ CMi (BD+09 1633) has been the subject of interest for the last ten years. The goal is to clarify the configuration and emission regions in the system.

Recent studies of the star show certain similarities with different types of symbiotic stars such as MWC 560 and T CrB [Zamanov et. al. 2021]. Photometric and spectral observations of the system are needed to clarify the configuration.

This study is based on U, B, V, R observations of ZZ CMi during the last observational season (2024/2025). Other than looking for flickering we were interested in following the variability of brightness in the same period. Refining the photometric standards used is going to help for more precise observations of the object with telescopes of 0.3-0.7 m caliber.

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Every observation of the star is of great interest to us because it can help to clarify the stellar configuration of such objects.

Observations

In this study we present CCD photometry of ZZ CMi. The photometry was done by the 40-cm telescope at the Astronomical observatory of the Shumen University (AOShU) [Kjurkchieva et al. 2020].

The star was observed photometrically during three observational nights. In Table 1 is presented the journal of these observations, all of which are done with U, B, V and R filters. Expositions were: 80[s] with U, 30[s] with B, 10[s] with V and R.

Table 1. Journal of observations of ZZ CMi with the 40-cm telescope of the Shumen Astronomical Observatory

Date	Band	UT start – UT end hh:mm – hh:mm	N_{pts}	Average [mag]	σ [mag]	Amplitude [mag]
17 November 2024	U	02:33 – 3:15	10	11.806	0.029	< 0.388
	B		16	11.481	0.004	< 0.067
	V		16	10.165	0.007	< 0.022
	R		16	8.904	0.004	< 0.041
19 January 2025	U	19:05 – 20:15	26	11.24	0.021	< 0.225
	B		27	11.267	0.009	< 0.041
	V		26	9.957	0.008	< 0.035
	R		26	8.746	0.006	< 0.034
05 Mart 2025	U	17:44 – 22:45	112	11.352	0.015	< 0.488
	B		114	11.491	0.004	< 0.053
	V		113	10.169	0,002	< 0.034
	R		98	8.876	0.002	< 0.096

The following standard procedure was used for the reduction of the photometric data: de-biasing, dark frame subtraction and flat-fielding, using the software MaxImDL 6.4. We performed differential photometry using the first 3 standard stars of the Table 2. The magnitudes in U, B, and V filters of the first three standard stars (1, 2, 3 from Table 2) were taken from the article by Zamanov et al. [2021], while magnitudes in R filters were taken from the catalogue NOMAD-1 [Zacharias et al. 2004]. The magnitudes in all filters of the standard stars 4, 5 and 6 (Table 2) were taken from the catalogue Gaia Attitude Star Catalog [Smart, R. L. & Nicastro, L. 2014]. Some of the standards coincide with those used by Henden and Munari [2006] and APASS DR9 [Henden, A. A., et.al., 2015].

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We transformed the data using equations from article Kjurkchieva et. al. [2020] and Georgiev et. al. [2023].

Table 2. Photometrical standards used during the processing of the observations- ZZ CMi

Label	Star ID	RA(2000)	Dec(2000)	U	B	V	R
1	TYC 764- 474-1	07:24:25.93	+09:01:23.89	10.170 +/- 0.008	10.061 +/- 0.001	9.826 +/- 0.001	9.800 +/- 0.0021
2	TYC 763-411-1	07:24:09.03	+08:45:42.53	10.670 +/- 0.013	10.563 +/- 0.035	10.481 +/- 0.002	10.480 +/- 0.0043
3	TYC 764-314-1	07:24:45.77	+08:57:43.17	11.320 +/- 0.028	11.220 +/- 0.0032	11.155 +/- 0.0034	11.120 +/- 0.0072
4	TYC 763-347-1	07:23:58.78	+09:02:19.07	12.160	11.420	10.437	9.860
5	TYC 764-602-1	07:24 :49.22	+08:59:24.92	13.080	11.670	10.310	9.580
6	TYC 763-890-1	07:24:11.55	+08:49:45.85	12.270	12.250	11.732	11.410

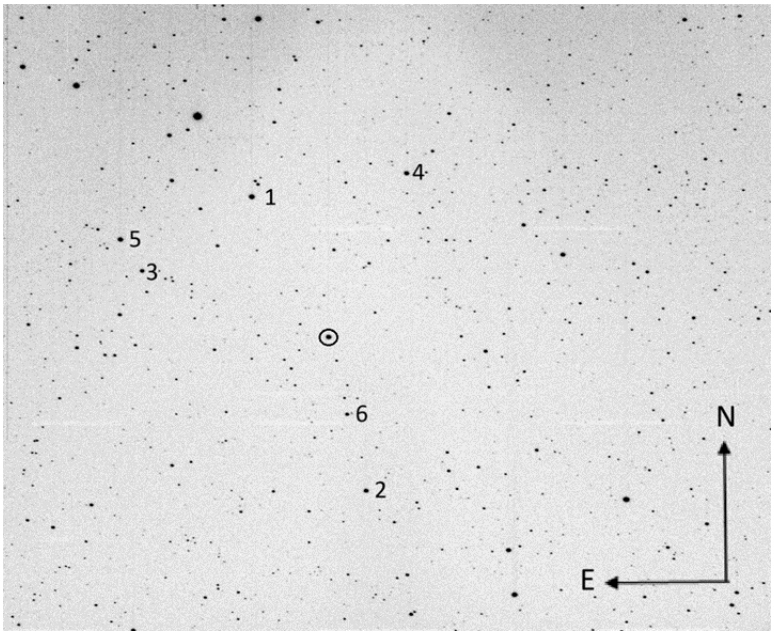

Figure 1. The field with the standard stars for the ZZ CMi

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The field with the standard stars marked is shown in Fig. 1. In figure one, the star ZZ CMi is marked with a circle, and all standards are marked with numbers. They are arranged by brightness. The figure uses one of the frames obtained with our telescope in filter V. The field is 35' x 35'.

In 2024, the star was observed on November 17 for one hour Fig. 2. The absence of the last few points of the light curve in U is due to a failure in the telescope's guiding system. At larger exposures, such as in the U band, this significantly affects the quality of the image. In 2025 so far, we have observed the star 1 time in January and 1 time in March and the results are shown in Fig. 3 and Fig. 4.

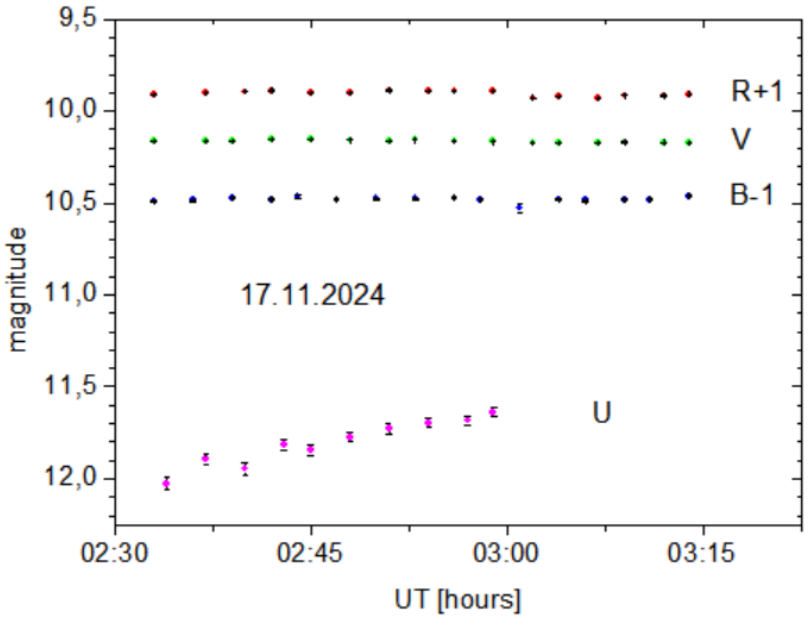

Figure 2. Observation ZZ CMi in 17.11.2024

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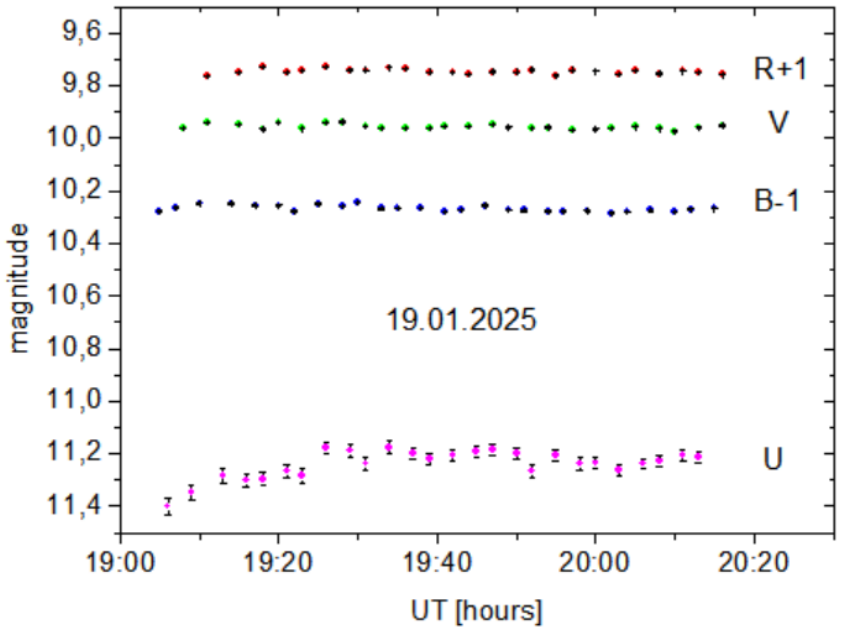

Figure 3. Observation ZZ CMi in 19.01.2025

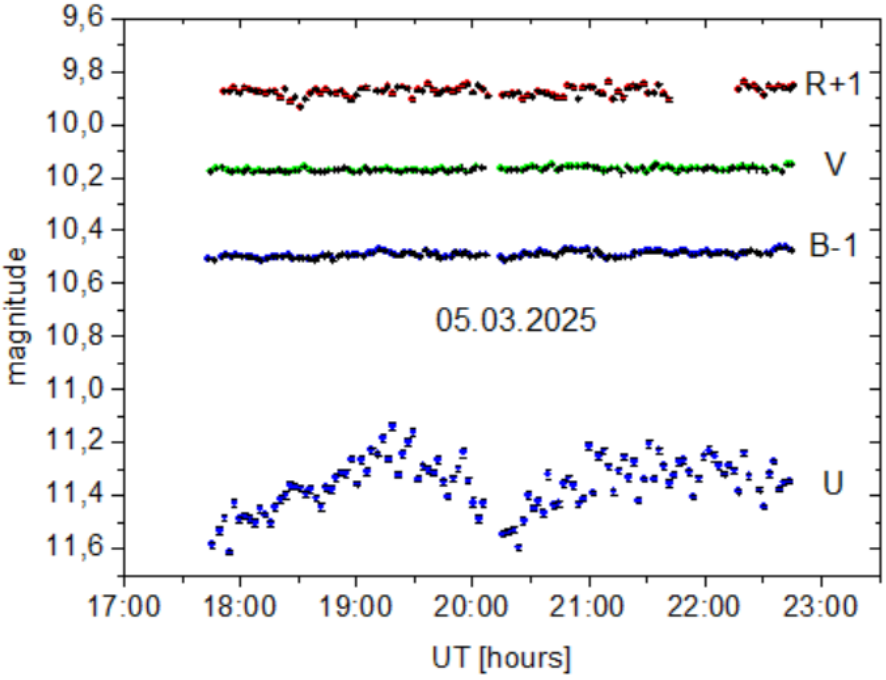

Figure 4. Observation ZZ CMi in 05.03.2025

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Results

The results of our photometric observations are summarized in Table 1. The results from photometric observations are:

1. Flickering variability is clearly visible in our observations in U band from 2024 November 17 see (Fig. 2), 2025 January 19, (Fig. 3), and 2025 March 5 (Fig. 4). The amplitude is 0.39 mag, 0.23 mag and 0.49 mag respectively.

2. A decrease of the brightness in U band of 0.2 mag for 1-2 hours is visible in the observations in all three nights Figs 2, 3 and 4. The simultaneous observations in these three nights do not indicate similar changes in B and V bands.

3. An interesting fact is the appearance of brightness variations with an amplitude of 0.04 mag to 0.09 mag in filter R on the night of 05.03.2025.

Our average photometric values in the B and V bands show similarity to those obtained in early 2024 [Zamanov et.al. 2024] from the 0.4 m Jaen Telescope, Spain [Martı et al. 2017].

Discussion

ZZ CMi is a symbiotic star that consists of a white dwarf and a red giant star, with the orbital period likely to be ~ 440 d [Wiecek et al. 2010]. Tshernova [1949] found that ZZ CMi is a long-period variable star. Even today, the star remains misunderstood because it has atypical manifestations for a classic symbiotic star. Such are, for example - the colours are bluer at a minimum and the strengths of the emission lines are unusual, with $H\gamma > H\beta$ [Belczynski et al. 2000] and others.

The first indication that ZZ CMi has intranight variability is given by Stoyanov [2012]. The presence of flickering in U band with the observed amplitude strongly suggests that the hot component is a white dwarf [see Sect. 4.1 in Sokoloski & Bildsten 2010].

From our observations in U we established a variation range of 11.24 - 11.80 mag. Using the GAIA eDR3 [Gaia Collaboration et al. 2021] the model by Bailer-Jones et al. [2021] provides distance d = 1240 ± 20 pc for ZZ CMi. With this distance and E(B-V) = 0 we estimate that the absolute U band magnitude is in the range $-3.9 < M_U < -3.3$ mag. Comparing these values with the ones given by Zamanov et. al. [2021] we confirm that the hot component of ZZ CMi is similar to the one of T CrB. More questions arise from the similarity of the Hα spectra of ZZ CMi at a given time with those of MWC 560 [Tomov et. al. 1990] commented by Zamanov et. al. [2021]. Further investigation of this requires future observations to clarify the emission mechanisms in the system.

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Conclusion

Our observations during the last observational season of ZZ CMi confirms the presence of flickering in U band. The brightness of the system in the U band changes within an hour or two by 0.2 mag. The observations from March 2025 show a high level of variability in R band. Our observations also confirm the thesis of Zamanov et. al. [2012] that the hot component of the system is similar to that of T CrB. The similarity with T CrB is interesting and predetermines further observations of ZZ CMi in order to monitor the level of brightness and the presence of flickering. It can be expected that as the brightness of the system increases, the flickering will disappear.

The work shows multiple convenient standard stars around the symbiotic star ZZ CMi.

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