Searching for Polars among MLS CV Candidates Using 3BS

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Abstract. We used our 3BS search method to find polars among MLS cataclysmic variables candidates. Objects for observations were selected using analysis of long-time CRTS photometry. We obtained color photometry of three objects MLS111021:204455-162230, MLS180917:001928+483906, MLS180917:224712+461815. Color indexes of objects MLS111021:204455-162230 and MLS180917:001928+483906 correspond to K3 giant and F6 star close to Main Sequence respectively. Analysis of archived data showed that these are objects of the RR Lyr type. The third object showed required color indexes and fast flux drop and rise during observations, indicating for eclipse presence. Thus we classified it as a polar.

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1 Polars and 3BS

Polars (Cropper 1990; Warner 1995) are close magnetic cataclysmic systems consisting of a white dwarf, whose magnetic field strength exceeds 10 MG and a red dwarf of a late spectral type. In the case when the field strength exceeds 10 MG, the matter is directed along the magnetic field lines and accrets near the magnetic poles of the white dwarf. The main continuum emission region is compact and, therefore, the out-of eclipse amplitude of the orbital brightness variability can reach 2m. In addition to the strong variability of the emission, the classification criterion could serve the presence of circular and linear polarization, the He II λ4686 strong emission line comparable in intensity with the Hβ line (Voikhanskaya 1987; Patterson & Skillman 1994), and the harmonics of the cyclotron emission.

Using the last feature we developed the 3BS method to search polar candidates (Gabdeev et al. 2020). Comparing the fluxes in two emission lines He II λ4686 (the SED470 filter) and Hα (the SED656 filter), we can distinguish the polars. In practice, the method was applied at the MMPP (Multi-Mode Photometer Polarimeter) of the Zeiss-1000 telescope of SAO RAS. Here we present results of observations of three objects from MLS[4] (Drake et al. 2009) list of CV candidates obtained in October 2020.

2 Observations

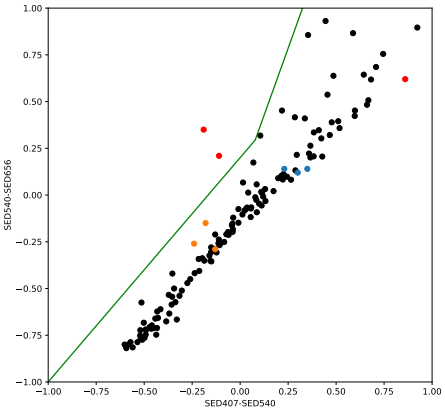

Fig. 1. ([SED470-SED540]-[SED540-SED656]) color diagram. Dots: black-single stars of different spectral classes from Pickles (), blue - MLS111021's color indexes, orange - MLS180917(1), red - MLS180917(2). Green line illustrates criteria to choose polar candidates from Gabdeev.

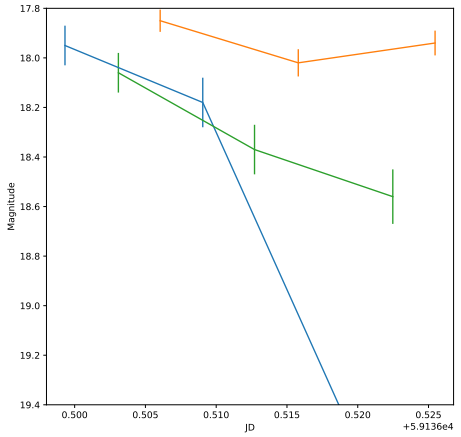

Fig. 2. Light curves of MLS180917(2). Blue - SED470, green - SED540, orange - SED656.

Observations were carried out at the MMPP of the Zeiss-1000 SAO RAS telescope. The Raptor Eagle V camera with the EEV42-40 CCD (2048×2048 pixels) was used as a detector. The field of view was $7'$ with a resolution of $0.''333$/pixel. The camera operating temperature, 90 C^o was achieved by water cooling. The observations were carried out in October 2020, on the 13th and

[4] http://nesssi.cacr.caltech.edu/MLS/CRTSII_CV.html

17th. One observation cycle of an object consists of three frames in the SED470, 540, and 656 filters. To eliminate random factors, three cycles are conducted.

The observations were reduced in the IDL[5] and Python[6] frameworks using the software for automatic search and photometry of field objects of astronomical images SExtractor (Bertin & Arnouts 1996). We performed the primary reduction of frames, the removing of the electronic zero (BIAS), flat-field division (FLAT), and the cosmic ray removal. Observations log presented in Table 1.

Table 1. Observations log

Object name	Mean JD	Exposures	Photometric limit
MLS180917:001928+483906	59136.481	300,240,240	20.9±.43,20.4±.24,20.8±.39
MLS180917:224712+461815	59136.512	300,240,240	19.42±.33,20.1±.45,20.0±.35
MLS111021:204455-162230	59140.139	45,60,60	18.8±.37,19.1±.32,19.2±.37

3 Analysis of Observations

Results of color photometry are presented in Table 2. Two objects MLS111021:204455-162230 and MLS180917:001928+483906 (hereafter MLS111021 and MLS180917(1)) didn't show brightness and color index variability. On the color diagram, the indexes were in the range for single stars (Fig. 2). For MLS111021 the indexes corresponded to K3 giant and for MLS180917(1) to F6 star close to Main Sequence. Searching through archived catalogues in Vizier [7], it was found that thees objects were earlier classified as RR Lyr stars. The MLS111021 period of variability $P = 0.^d535117(7)$ was found using the built-in CRTS database tool[8]. For the record, there are no access to CRTS photometric data for MLS180917(1) and MLS180917(2).

Object MLS180917:224712+461815 (hereafter MLS180917(2)) showed required color indexes (Fig. 2). Also, the object showed a strong brightness variation. The general trend for a decrease in brightness continued by fast drop. In the third cycle, our pipeline didn't detect the object in filter SED470. Manual reduction allowed to find the source. It was on the limit of detection. Thus, we assigned to the object the photometric limit for that image 19.42. As you can see on Fig. 2, the fall on brightness lasted about $0.^d007$ or 10 minutes. Hence, we assumed that this object has an eclipse. Using the criteria published by Gabdeev et al. (2020) we classified MLS180917(2) as a polar.

[5] https://www.harrisgeospatial.com/Software- Technology/IDL
[6] https://www.python.org/
[7] https://vizier.u-strasbg.fr/viz-bin/VizieR
[8] http://nunuku.caltech.edu/cgi-bin/getcssconedb_release_img.cgi

Table 2. Observations log

Object	Mag SED540	SED470-SED540	SED540-SED656
	17.34	-0.24	-0.26
MLS180917(1)	17.37	-0.18	-0.15
	17.12	-0.13	-0.29
	18.08	-0.11	0.21
MLS180917(2)	18.37	-0.19	0.35
	18.56	0.86	0.62
	14.17	0.23	0.14
MLS111021	14.17	0.35	0.14
	14.16	0.30	0.12

4 Conclusions

We used the 3BS method for three MLS cataclysmic variables candidates. Color photometry of objects MLS111021 and MLS180917(1) showed that they are single stars with color indexes corresponding to K3 giant and F6 Main Sequence star respectively. Using archive data it was found that these objects are RR Lyr type stars. For MLS111021 we found period of the variability $P = 0.^d535117(7)$. The MLS180917(2) object showed required by the criteria color indexes and fast flux drop and rise during observations, indicating for eclipse presence. We classified it as a polar. More observations required for further study.

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