"Peremennye Zvezdy",
Prilozhenie,
vol. 22, N 4 **(2022)**

New variable stars in open cluster Berkeley 59

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ISSN 2221–0474

DOI: 10.24412/2221-0474-2022-4

Received: 30.09.2022; accepted: 22.12.2022
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#	Name	Other	Coord (J2000)	Type	Max	Min	System	Period	Epoch (JD)	type	Sp	Comment	L.Curve	Find.Chart	Data
1		2MASS 00021457+6814518	00 02 14.578 +68 14 51.87	BY:	11.623	11.662	R	1.83	2459639.17	max			BE59_2526_lc.png	BE59_2526_fc.png	data_2526.txt
2		2MASS 00023844+6724095	00 02 38.448 +67 24 09.51	EA	13.29	14.08	R			min		Comm. 2	BE59_1220_lc.png	BE59_1220_fc.png	data_1220.txt
3		2MASS 00030008+6740139	00 03 00.088 +67 40 13.94	BY	13.009	13.044	R	5.86	2459681.27	max			BE59_1211_lc.png	BE59_1211_fc.png	data_1211.txt
4		2MASS 00034393+6806156	00 03 43.935 +68 06 15.68	ELL:	12.554	12.587	R	0.5295	2459653.418	min			BE59_2351_lc.png	BE59_2351_fc.png	data_2351.txt
5		2MASS 00043432+6744541	00 04 34.327 +67 44 54.12	EW	12.324	12.394	R	0.65851	2459695.317	min		Comm. 5	BE59_1930_lc.png	BE59_1930_fc.png	data_1930.txt
6		2MASS 00054660+6637239	00 05 46.601 +66 37 23.90	DSCTC	14.006	14.041	R	0.185898	2459664.3324	max			BE59_0118_lc.png	BE59_0118_fc.png	data_0118.txt
7		2MASS 00061124+6815597	00 06 11.241 +68 15 59.71	ACV:	11.57	11.65	R	2.702	2459648.452	max			BE59_1905_lc.png	BE59_1905_fc.png	data_1905.txt
8		2MASS 00063952+6640486	00 06 39.522 +66 40 48.66	BY	12.54	12.62	R	20.4	2459639.1	max			BE59_0127_lc.png	BE59_0127_fc.png	data_0127.txt
9		2MASS 00075699+6707443	00 07 56.995 +67 07 44.34	EA	12.94	13.7	R	10.814	2459680.383	min		Comm. 9	BE59_0802_lc.png	BE59_0802_fc.png	data_0802.txt
10		2MASS 00082449+6731106	00 08 24.498 +67 31 10.64	I	13.71	13.98	R			other			BE59_1621_lc.png	BE59_1621_fc.png	data_1621.txt
11		2MASS 00100150+6754173	00 10 01.505 +67 54 17.39	GDOR	11.99	12.08	R	0.4823	2459495.381	max			BE59_1766_lc.png	BE59_1766_fc.png	data_1766.txt
12		2MASS 00112407+6725354	00 11 24.076 +67 25 35.45	GDOR:	12.819	12.871	R	1.66	2459655.46	max			BE59_1545_lc.png	BE59_1545_fc.png	data_1545.txt
13		2MASS 23520884+6759121	23 52 08.845 +67 59 12.16	DSCTC	14.143	14.162	R	0.0651	2459646.271	max			BE59_4439_lc.png	BE59_4439_fc.png	data_4439.txt
14		2MASS 23521902+6722196	23 52 19.024 +67 22 19.65	EA	14.93	15.13	R	0.9683	2459653.348	min		Comm. 14	BE59_3582_lc.png	BE59_3582_fc.png	data_3582.txt
15		2MASS 23540741+6804358	23 54 07.420 +68 04 35.89	BY	12.34	12.37	R	23.6	2459655.4	max			BE59_4609_lc.png	BE59_4609_fc.png	data_4609.txt
16		2MASS 23541481+6726051	23 54 14.815 +67 26 05.14	BY:	11.237	11.258	R	0.57316	2459654.473	max			BE59_3737_lc.png	BE59_3737_fc.png	data_3737.txt
17		2MASS 23563698+6706382	23 56 36.983 +67 06 38.22	EA	13.42	13.63	R			min		Comm. 17	BE59_3357_lc.png	BE59_3357_fc.png	data_3357.txt
18		2MASS 23581106+6800323	23 58 11.068 +68 00 32.33	BY:	11.652	11.668	R	0.844	2459656.285	max			BE59_4287_lc.png	BE59_4287_fc.png	data_4287.txt
19		2MASS 23584160+6758086	23 58 41.603 +67 58 08.65	EB	16.27	16.65	R	0.6173	2459495.255	min		Comm. 19	BE59_4164_lc.png	BE59_4164_fc.png	data_4164.txt
20		2MASS 23585966+6710019	23 58 59.662 +67 10 01.94	EA	11.18	11.23	R	1.9385	2459658.222	min		Comm. 20	BE59_3372_lc.png	BE59_3372_fc.png	data_3372.txt

Comments:

2. We observed only one minimum. HJDmin = 2459677.195.

5. MinII = $12^{m}.39$ R.

9. MinII = $13^{m}.49$: R. Eccentric orbit. MinII–MinI = 0.33 P . Period $3^{d}.604$ is possible.

14. MinII = $14^{m}.96$ R. D = 0.11 P.

17. We observed only one minimum. HJDmin = 2459495.36.

19. MinII = $16^{m}.48$ R. The star is listed in the ZTF catalog of periodic variable stars (Chen et al. 2020) as EW.

20. MinII = $11^{m}.21$ R. D = 0.09 P.

Remarks:

Kourovka Planet Search (KPS, Burdanov et al. 2016; Burdanov et al. 2018) is a project aimed at finding new transiting exoplanets using the Master-II-URAL telescope. Our pilot observations were obtained during short and bright summer nights of 2012 at the Kourovka Astronomical Observatory of the Ural Federal University. In 2017, the project was renamed as the Galactic Plane eXoplanet Survey (GPX, Benni 2017). We observed the field of the Open Cluster (OC) Berkeley 59 centered at α = 00h 02m 14.0s, δ = +67d 25m 00s (J2000.0).

The Master-II-URAL consists of two parallel optical telescopes (40-cm aperture, 1:2.5 focal ratio) installed on the same mount and equipped with two Peltier-cooled Apogee Alta U16M CCD cameras. The image scale is 1.85"/px. Observations can be performed simultaneously in two filters of the Johnson– Cousins BVRI photometric system (Lipunov et al. 2010). All observations with the MASTER- II-Ural telescope were made in automatic mode. Prior to each observation night, dark frames were obtained with the necessary CCD temperature; under good weather conditions, every morning the telescope obtained twilight sky flat-field frames in the appropriate filter.

Observations of the OC Berkeley 59 were carried out during October 2021 – April 2022 for 44 nights. 5000 fits files were obtained in R and V bands with 50-second exposures.

Astrometric reductions of all frames were performed using the Astrometry.net application (Lang et al. 2010). All objects were identified using 2MASS catalogue (Skrutskie et al. 2006). Initial photometric reductions and aperture photometry were performed in the IRAF package (Tody 1986). We used the Astrokit console application (Burdanov et al. 2014) for data post-processing. The program performs high- precision differential CCD photometry for thousands of stars and uses Robust Median Statistic criterion (Rose & Hintz 2007) to search for variable-star candidates. The photometric precision for stars from 11 to 16.5 mag was 0.008–0.08 mag, and 0.006–0.09 mag for V and R bands respectively.

From our initial sample of 5000 stars, we selected 39 variable objects whose light curves were inspected by eye. Variability has not been previously reported for 20 out of 39 objects in the international variable star index (VSX) database. To determine periods of variability, we used the light curve analysis tool by Kirill Sokolovsky. This application implements Lafler & Kinman (1965) and Deeming (1975) methods to search for periods as well as transforms Julian Dates to Heliocentric Julian Dates.

In this paper, we provide figures that consist of two panels. Star's instrumental magnitude as a function of Heliocentric Julian Date is given in the left panel and phase folded light curve is given in the right panel. When we could not define a period, we provide only the light curve as a function of Heliocentric Julian Date. In the figures, we used red color for R band, green color for V band data. For the sake of visibility, we shifted stars' magnitudes in V band by (V-R) value. Color indices are provided on top of each figure.

Acknowledgements:

This work was supported by Ministry of Science and Higher Education of the Russian Federation under the grant 075-15-2020-780.

The authors wish to thank Dr. Kirill Sokolovsky for providing his online light curve analysis tool.

This research made use of Aladin (Bonnarel et al. 2000), SIMBAD database (operated at the Centre de Données astronomiques de Strasbourg), the International Variable Star Index (VSX) database (operated at AAVSO, Massachusetts, USA).

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