The digitized First Byurakan Survey database. New carbon stars confirmed.

K. K. Gigoyan*

INAS RA V. Ambartsumian Byurakan Astrophysical Observatory (BAO), Byurakan 0213, Aragatzotn Province, Armenia

Abstract

Some amount of the new carbon (C) stars was confirmed among the sample of the Late-Type Stars (LTSs) candidates, selected on the Digitized First Byurakan Survey (DFBS) spectral plates. The DFBS is the digitized version of the First Byurakan Survey (FBS, or Markarian survey). The FBS was the first systematic survey of the extragalactic sky. This objective-prism survey was carried out in 1965-1980 by B. E. Markarian and colleagues using the 1 m Schmidt telescope of the Byurakan Astrophysical Observatory. In this work we present Gaia DR3 photometric data, spectra, light curves, distances, high above/below Galactic plane, radial velocities (RV), and other important physical characteristics from modern astronomical catalogues for some amount new confirmed DFBS carbon stars. The confirmation is based on Gaia DR3 BP/RP low-resolution spectral database. In previous studies of the DFBS plates, these objects were presented as LTSs candidates. Some objects are located more than 7 kpc from the Galactic plane. Four of them are N-type C stars, from which two are Mira-type variables. The remaining objects are CH-type giants at high Galactic latitudes. Most probably they present binary systems.

Keywords: *late-type stars: carbon stars*

1. Introduction

Markarian survey (or the First Byurakan Survey-FBS), was the first systematic survey of the extragalactic sky. This objective-prism (op) low-resolution survey was carried out in 1965-1980 by B. E. Markarian and collaborators using the 1 m Schmidt telescope of the Byurakan Astrophysical Observatory (BAO) and resulted in discovery of 1517 UV-excess galaxies (Markarian et al., 1989). FBS spectral plates have been used for a long time to search and study faint Late-Type Stars (LTS, M -type stars and C (carbon) stars)) at high Galactic latitudes (Gigoyan et al., 2001). All FBS spectral plates have now been digitized, resulting in the creation of the Digitized First Byurakan Survey (DFBS) database (on-line at https://www.ia2-byurakan.oats.inaf.it). All DFBS plates are analyzed with help of analysis softwares FITSView and SAOImage ds9. A second version of the "Revised and Updated Catalogue of the First Byurakan Survey of Late-Type Stars", containing data for 1471 M and C stars was generated (Gigoyan et al., 2019) CDS Vizier Catalogue https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=J/MNRAS/489/2030. This visualization allows to detect very red and faint C and N star candidates close to the detection limit in each plate (Gigoyan, 2022). Meanwhile, a large amount of such faint candidates detected on the DFBS plates, remained to be confirmation on spectral types. In this study we present some important data for newly confirmed CH-type and N-type C stars. This paper is structured as follows: Section 2 introduces the Gaia DR3 spectra for some amount of new confirmed C stars. Section 3 present Gaia DR3 important data for C stars. Phase dependent light curves for new C stars is presented in Section 4. Section 5 recalls the main results obtained for new objects and provide concluding remarks and future works.

2. Gaia DR3 spectra

The European Space Agency (ESA) mission Gaia (Gaia Collaboration, Prusti et al., 2016) has already released three catalogues to the astronomical community. With respect to previous Gaia Early Data Release 3 (EDR3, Gaia Collaboration, Brown et al., 2021), Gaia Data Release 3 (Gaia Collaboration, Vallenari et al.,

*karengigoyan@bao.sci.am

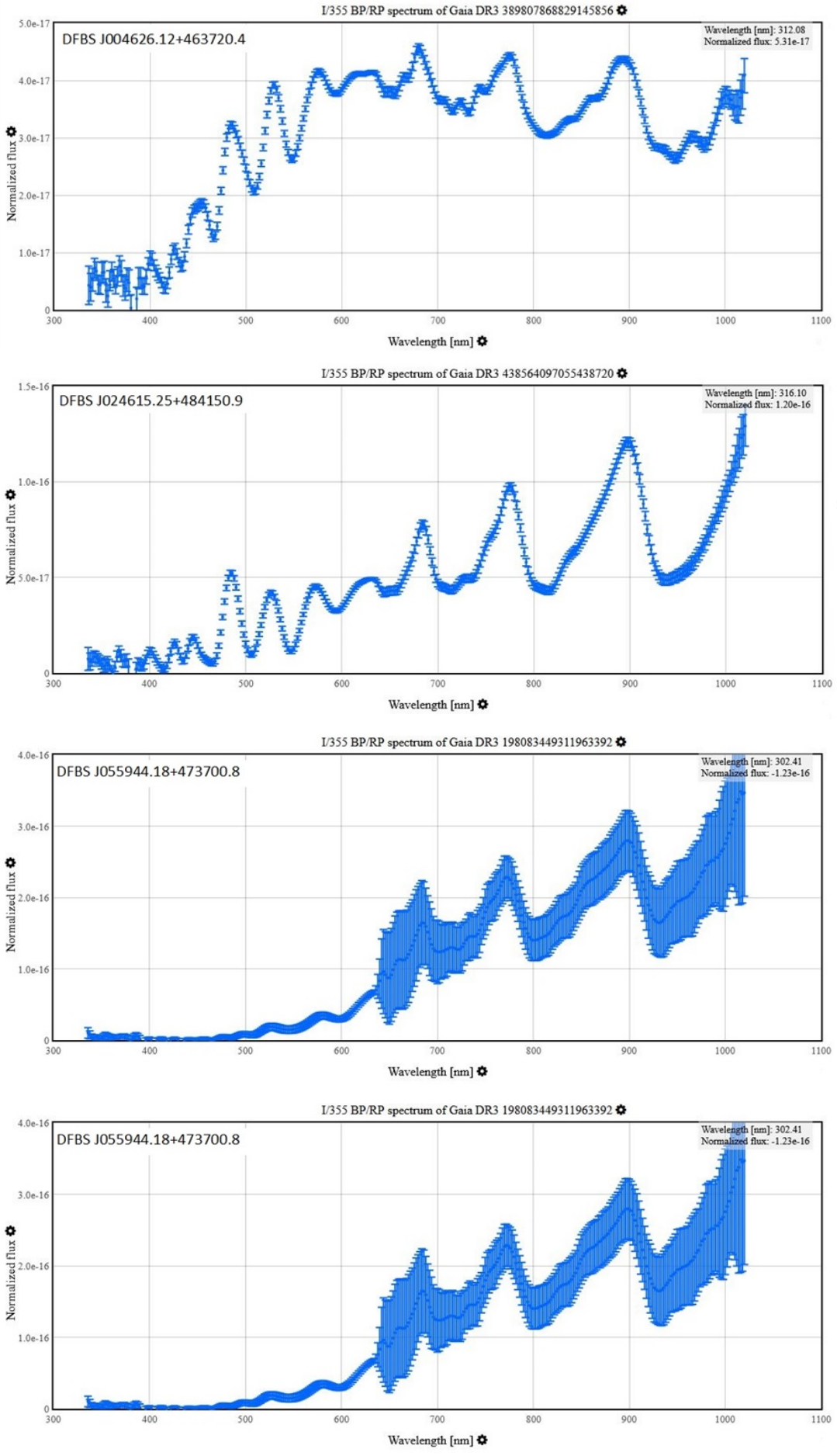

Figure 1. Gaia DR3 low-resolution spectra for new confirmed DFBS C stars.

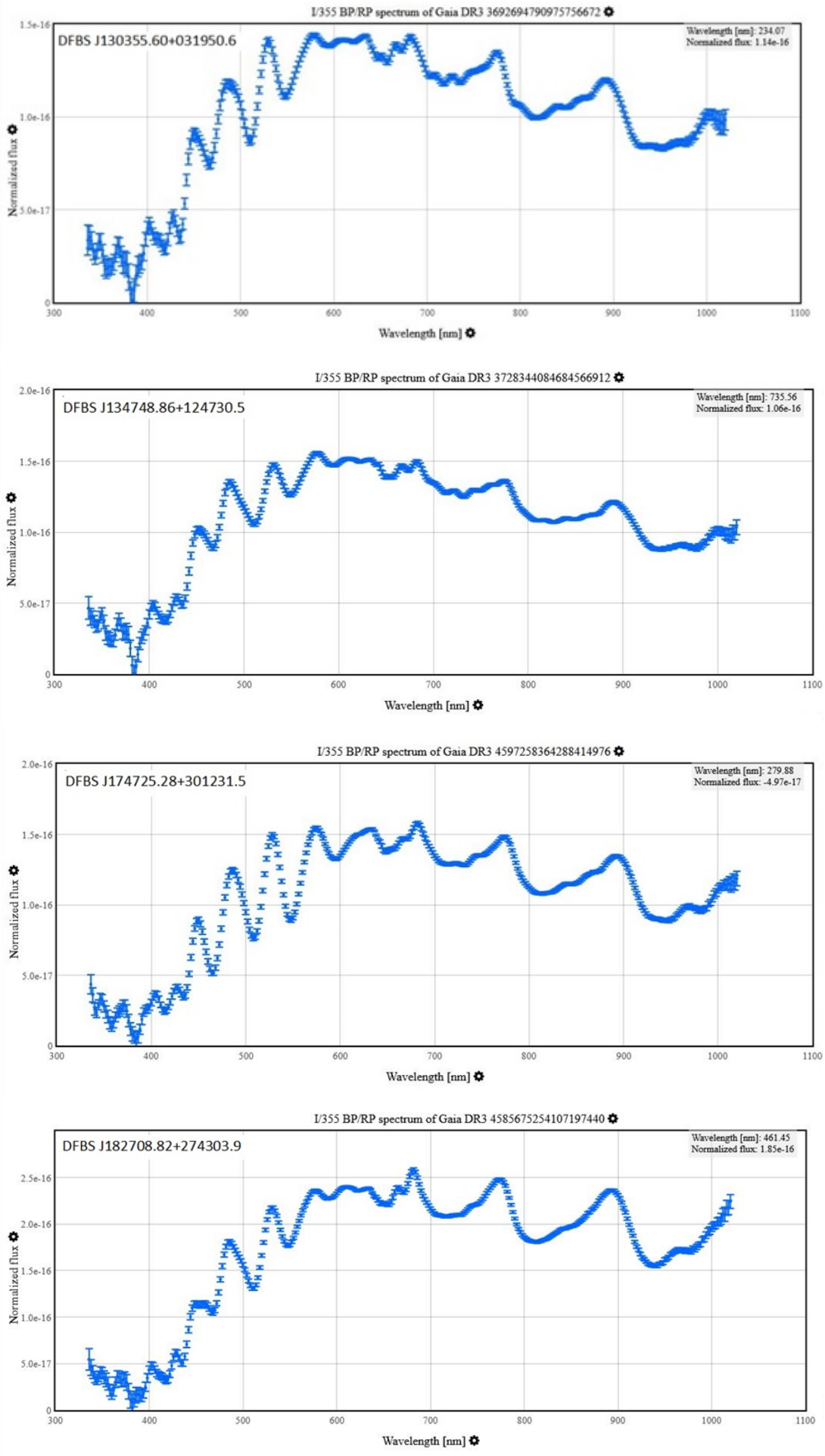

Figure 2. Gaia DR3 low-resolution spectra for new confirmed DFBS C stars.

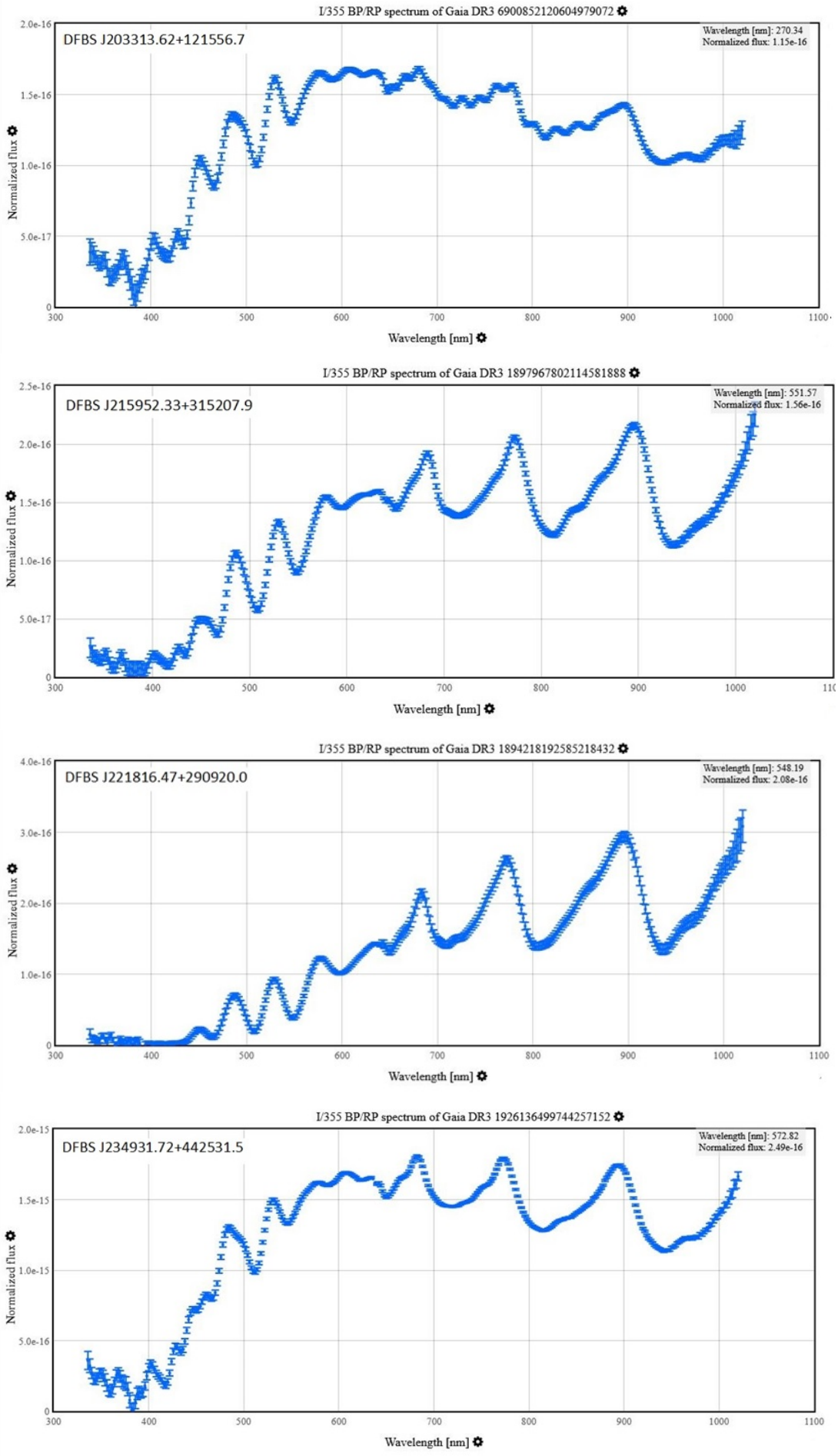

Figure 3. Gaia DR3 low-resolution spectra for new confirmed DFBS C stars.

Table 1. 15 DFBS candidates.

DFBS Number	Gaia DR3 Source Number	Gaia DR3 Source Number	SP. Type
J004626.12+463720.4	389807868829145856		C-CH
J024615.25+484150.9	438564097055438720		C-CH
J055944.18+473700.8	198083449311963392	NSVS 4490482	C-N
J082310.36-015325.7	3070045067018279040	ATO J125.7932-01.8905	C-N
J130355.60+031950.6	3692694790975756672		C-CH
J134748.86+124730.5	3728344084684566912		C-CH
J174725.28+301321.5	4597258364288414976		C-CH
J182708.82+274303.9	4585675254107197440		C-CH
J203313.62+121556.7	1755523764342918784		C-CH
J203956.64-063740.4	6908005165297040896		C-CH
J215432.69+373839.7	1949989717315919232		C-CH
J215952.33+315207.9	189796802114581888		C-CH
J221816.47+290920.0	1894218192585218432		C-CH
J234931.72+442531.7	1922548170531464448		C-CH

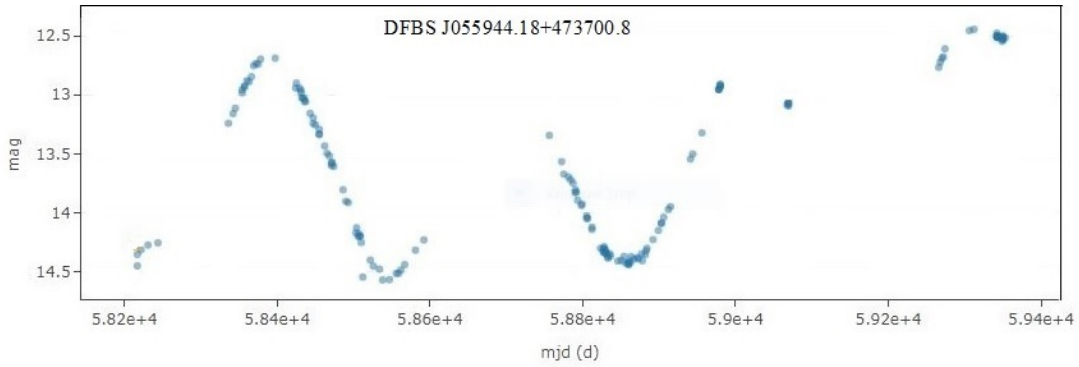

Figure 4. Zwicky Transient Facility light curve for DFBS J055944.18+473700.8 (available on-line at https://irsa.ipac.caltech.edu/missions/ztf.html/). X-axis presents the period in Julian Data and Y-axis presents ZTF g-band magnitude. The observational identifier is 74510700000050 (P ≈ 307d ay).

2023) introduces a number of new data products in Gaia DR3 (CDS Vizier Catalog I/355/gaiadr3/). Time-averaged mean spectra covering the optical to near-infrared (NIR) wavelength range 3300-10500 Å are published for approximately 220 million objects (Catalog I/355/spectra). Most of these objects are brighter than G=17.65 mag (De Angeli et al., 2023). M-type stars can be detected very easily in the Gaia DR3 lr spectral database by the presence of the broad absorption bands of the TiO molecule in the range 6500-7000 Å, 7000-7500 Å, and 8000-8500 Å, and C stars display strong Swan bands at 4383, 4737, 5165, and 5636 Å of the C_2 molecule (Gigoyan et al., 2024).

Table 1 presents 15 DFBS candidates, confirmed as C stars, it gives the DFBS Number, the Gaia DR3 (I/355/gaiadr3) source name, other association in SIMBAD database, and our spectral type determination (C -N or C-CH).

Figures 1, 2 and 3 present Gaia DR3 Catalogue BP/RP lr spectra for objects of Table 1. There are no spectra for object DFBS J215432.69+373829.7 in Gaia DR3 low-resolution database. We assume, that this object is N-type carbon stars according to location in J-K vs. BP-RP diagram (see more detail in Gigoyan et al. (2021).

3. Gaia DR3 photometric data. Distances and absolute magnitudes.

Table 2 presents Gaia DR3 Catalogue (VizieR CDS Catalogue I/355/gaiadr3) key data for new confirmed C stars and their high (Z) above/below the Galactic plane. The distance estimation is based on Gaia DR3 trigonometric parallaxes (absolutely the same value parallaxes, as presented in Gaia EDR3 catalogue (CDS

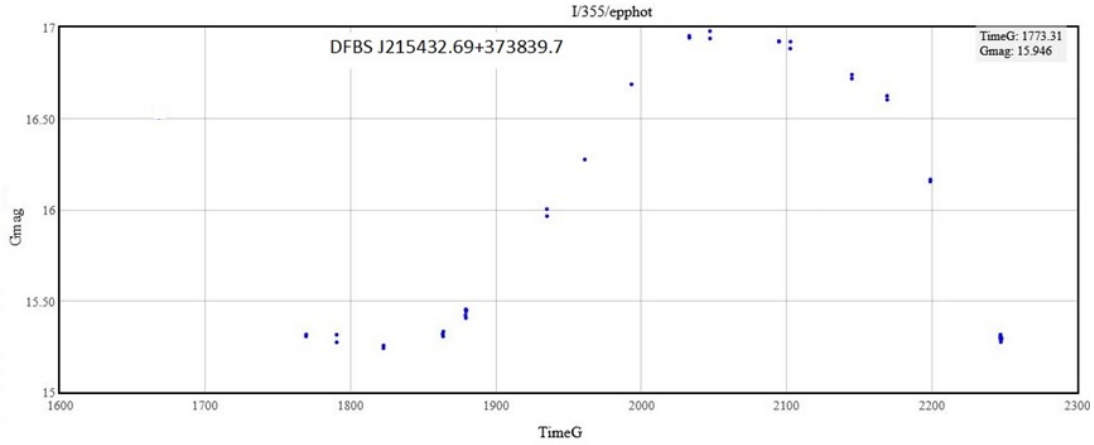

Figure 5. Phase dependent light curve for DFBS J215423.69+373839.7. This object is a Mire variable (P ≈ 450 day).

Table 2. Some important Gaia DR3 data for new confirmed carbon stars.

DFBS Number	Gaia G mag	BP-RP color	RV (km/s)	r(pc)	M(G)	Z(pc)
J004626.12+463720.4	14.68	1.53	-247.70(±3.14)	9783(±1500)	-0.50(±0.30)	-2737(±400)
J024615.25+484150.9	14.28	2.17	-137.35(±2.57)	6642(±800)	-0.20(±0.07)	-1147(±150)
J055944.18+473700.8	13.45	3.03	-33.70(±0.99)	9169(±1000)	-1.50(±0.20)	1850(±100)
J082310.36-015325.7	14.19	2.63	+210.10(±0.87)	11560(±900)	-1.10(±0.1)	3833(±300)
J130355.60+031950.6	13.35	1.33	-81.20(±1.72)	8791(±1000)	-1.37(±0.3)	8031(±800)
J134748.86+124730.5	13.28	1.28	-47.94(±1.58)	4680(±800)	-0.20(±0.1)	4411(±600)
J174725.28+301231.5	13.30	1.44	-351.18(±0.92)	6690(±400)	-0.80(±0.15)	2953(±100)
J182708.82+274303.9	12.77	1.49	-130.77(±0.38)	7541(±500)	-1.61(±0.16)	2250(±100)
J203313.62+121556.7	20.03	0.89		2415(±500)	??	??
J203956.64-063740.4	13.57	1.58	-283.63(±0.47)	9035(±1000)	-1.20(±0.20)	-4117(±400)
J215432.69+373839.7	16.16	4.50	-19.28(±0.03)	4758(±1000)	+2.77(±0.1)	-1-80(±200)
J215952.33+315207.9	13.18	1.76	-491.45(±0.43)	11288(±600)	-2.08(±0.1)	-3533(±200)
J221816.47+290920.0	13.17	2.32	-110.71(±0.31)	13504(±2500)	-2.48(±0.20)	-5237(±900)
J234931.72+442531.7	10.64	1.49	-13.93(±1.91)	1658(±40)	+1.04(±0.3)	-487(±5)

Vizier Catalog I/350/gaiaedr3). Therefore, we used the distance information from Gaia EDR3 by Bailer-Jones et al. (2021). We estimate the absolute G-band magnitude via the usual equation:

$$M(G) = G - 5Logr + 5 - A(G) \quad (1)$$

4. Variability

The object DFBS J055944.18+473700.8 is classified as Mira -type variable by Usatov & Nosulchik (2008). Phase dependent light curve for this object is available in "ASAS-SN Variable Star Database"(online at https://asas-sn.osu.edu/variables/, DFBS J055944.18+473700.8= ASASSN-V J055944.17+473700.7, Vmean = 14.98 mag), Figure 4 below shows ZTF (Zwicky Transient Facility (Masci et al., 2019) light curve for N-type C star DFBS J055944.18+473700.8. X-axis presents the period in Julian Data and Y-axis presents ZTF g-band magnitude. The observational identifier is 74510700000050 (P ≈ 307day). Figure 5 presents Gaia DR3 G-band magnitude phase dependent light curve for object DFBS J215432.69+373839.7. Figure 6 presents phased light curves for DFBS J174725.28+301231.5 and DFBS J182708.82+274303.9.

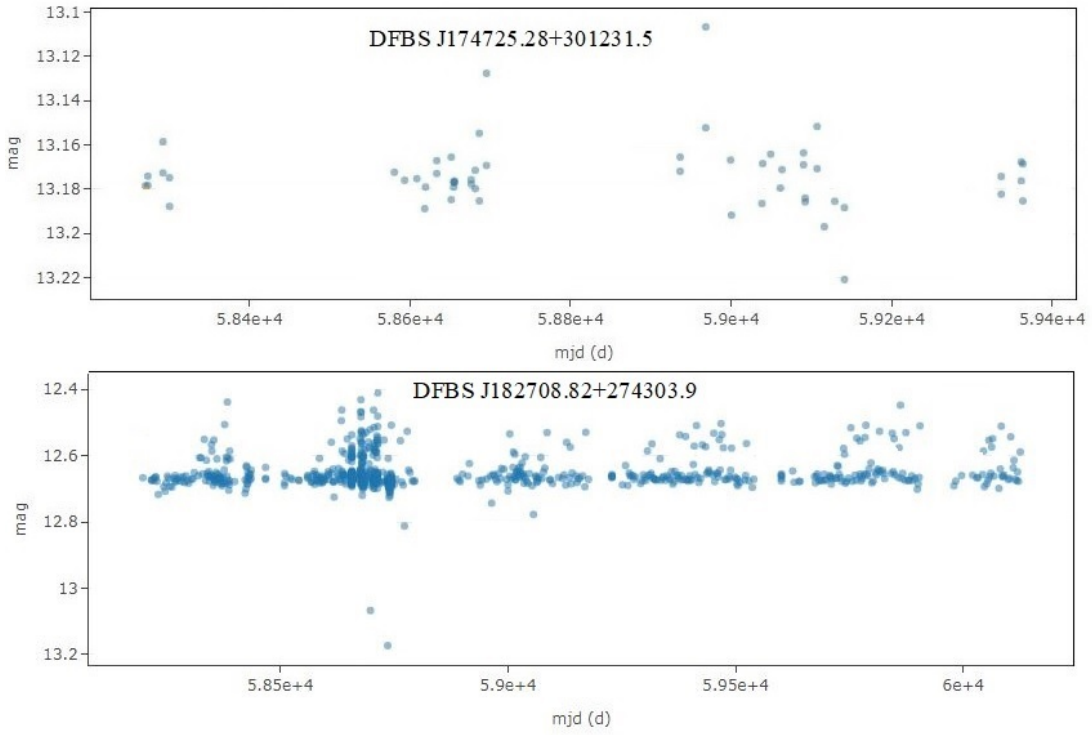

Figure 6. ZTF phased light curves in r-band for DFBS J174725.28+301231.5 and for DFBS J182708.82+274303.9. For last object the periodic variability in r-band with amplitude $\triangle$m $\approx$ 0.3 mag is evident.

5. Summary and future works

We present data for 15 new detected DFBS Carbon stars which are presented previously as C star candidates. We plan to carry many-sided investigations of near 160 FBS carbon stars, such as distribution in our Galaxy, kinematics, absolute magnitudes, masses, et al. in near future.

References

Bailer-Jones C. A. L., Rybizki J., Fouesneau M., Demleitner M., Andrae R., 2021, Astron. J. , 161, 147

Brown A. G. A., et al., 2021, Astron. Astrophys. , 650, C3

De Angeli F., et al., 2023, Astron. Astrophys. , 674, A2

Gigoyan K. S., 2022, Communications of the Byurakan Astrophysical Observatory, 69, 90

Gigoyan K. S., Abrahamyan H. V., Azzopardi M., Russeil D., 2001, Astrophysics, 44, 328

Gigoyan K. S., Mickaelian A. M., Kostandyan G. R., 2019, MNRAS, 489, 2030

Gigoyan K. S., Lebzelter T., Kostandyan G. R., Karapetyan E., Baghdasaryan D., Gigoyan K. K., 2021, , 38, e051

Gigoyan K. S., Gigoyan K. K., Sarkissian A., Kostandyan G. R., Meftah M., Bekki S., 2024, Astrophysics, 66, 470

Markarian B. E., Lipovetsky V. A., Stepanian J. A., Erastova L. K., Shapovalova A. I., 1989, Soobshcheniya Spetsial'noj Astrofizicheskoj Observatorii, 62, 5

Masci F. J., et al., 2019, Publ. Astron. Soc. Pac. , 131, 018003

Prusti T., et al., 2016, Astron. Astrophys. , 595, A1

Usatov M., Nosulchik A., 2008, Open European Journal on Variable Stars, 0087, 1

Vallenari A., et al., 2023, Astron. Astrophys. , 674, A1