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The Third Catalogue of the First Byurakan Survey of Late-Type Stars

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Abstract

A new value-added catalogue of late-type stars (LTSs), including M dwarfs, M giants, as well as new C (carbon) stars of N and CH types, was published from the analysis of the Digitized First Byurakan Survey (DFBS) spectral database. 1091 LTSs have been confirmed (243 M giants, 834 M dwarfs, and 14 C stars). All these objects were selected as LTS candidates when analysing the DFBS plates. For spectral type confirmation, the Gaia DR3 low-resolution BP/RP spectroscopic database has been used. To clarify the nature of the newly confirmed objects, Gaia DR3 photometric data and transiting Exoplanet Survey satellite (TESS) Input Catalog (TIC) data (masses, radii, effective temperatures, colors, distances, etc.) have been used. Using distances derived from the parallax in Gaia DR3, BP-RP color versus G-band absolute magnitude diagram (color-absolute magnitude diagram-CaMD) were constructed. Part of the newly confirmed M dwarfs presents binary systems.

Keywords: *Catalogues: stars late type: astronomical databases: surveys*

1. Introduction

The First Byurakan Survey (FBS), also known as the Markarian survey, was carried out with the 1 m Schmidt telescope at the Byurakan Observatory (BAO, Armenia) using a low-dispersion (1800 Å/mm at Hγ) thin 1.5 degree objective prism throughout a useful field of 4^0 x 4^0. The FBS is segmented into 28 parallel belts covering the entire northern sky and part of the southern sky at high Galactic latitudes with $\delta > -15^0$ and $|b| > 15^0$. Various Kodak emulsions were used during the observations (IIF, IIaF and 103aF), providing a spectral range of 3400-6900 Å. The limiting magnitude on the best plates reached $\sim$ 17.5 in photography. The FBS was originally conducted to search for galaxies with ultraviolet excess. In total, 1515 UVX galaxies have been discovered (Markarian et al., 1989).

The large spectral range of the FBS plates (3400-6900 Å) is well suited to identify various types of objects, especially late-type stars (LTSs, cool M – type or C-type (carbon) stars). C stars can be identified through the presence of the Swan bands of the C_2 molecule at 4737, 5165 and 5636 A. Late M-type star spectra can easily be distinguished thanks to the TiO molecule absorption bands (Gigoyan et al. 2001). Later, two catalogues of FBS LTSs were generated (Gigoyan & Mickaelian, 2012, Gigoyan et al., 2019).

All FBS plates have now been digitized, resulting in the creation of the Digitized First Byurakan Survey (DFBS) database (Mickaelian et al., 2007) (spectra are now available online at https://www.ia2-byurakan.oats.inaf.it/). All DFBS plates have been analyzed with the help of standard data visualization software (see Gigoyan 2022 for more detail), which resulted in the detection of about 3060 faint LTS candidates. To clarify all spectral types of all 3060 faint LTS candidates, the Gaia DR3 BP/RP spectroscopic database has been used to verify the spectral types for the candidates.

2. Gaia BP/RP Spectroscopic Data Base. New Confirmations.

The European Space Agency (ESA) mission Gaia (Gaia Collaboration; Prusti et al., 2016) has already released three catalogues to the astronomical community. Gaia Data Release 3 (DR3, Gaia Collaboration;

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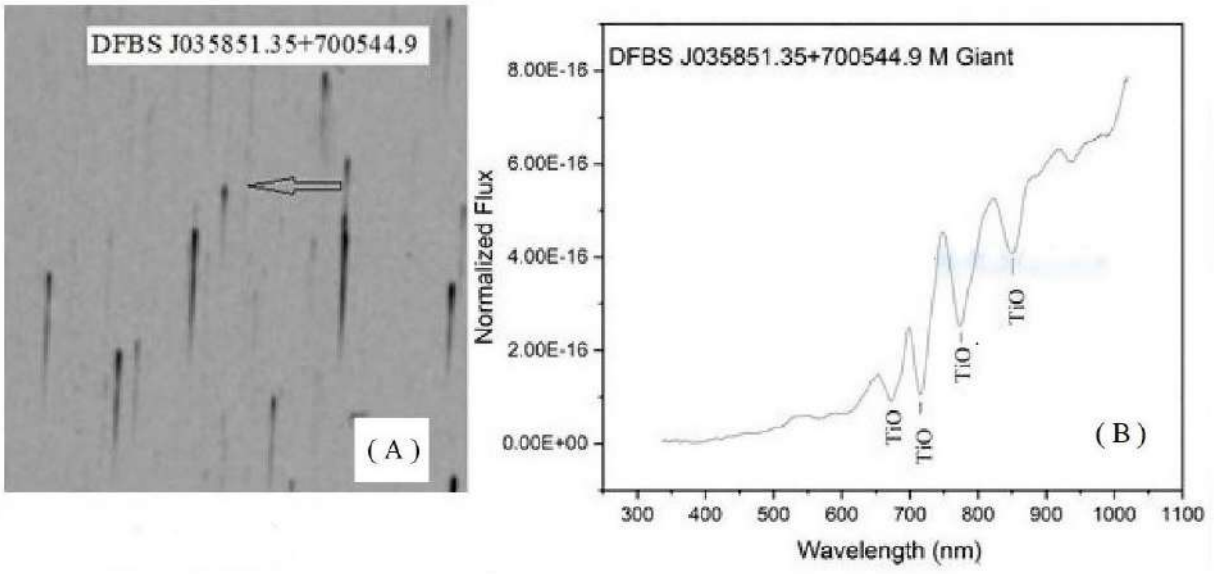

Figure 1. DFBS lr spectral shape (A) and Gaia DR3 BP/RP spectra (B) for new confirmed M giant DFBS J035851.35+700544.9. G mag =12.679, T_eff = 3269 K, TIC Catalogue number is 85987534.

Vallenari et al., 2023) introduces a number of new data products based on the same source catalogue, including a total of 1.8 billion objects (SIMBAD CDS Visier Catalog I/355/gaiadr3/). Gaia BP(Blue) and RP(Red) photometer spectra are among the new products in the DR3 database. Spectra in the wavelength range 3360-10200 Å, R=$\lambda/\delta\lambda \approx 25 - 100$), have been secured for nearly 220 million objects (CDS VizieR Catalog I/355/spectra, mainly for objects brighter than G = 17.65 mag. (Carrasco et al., 2021, De Angeli et al., 2023).

Our list of all LTS candidates is cross-matched with the Gaia DR3 BP/RP spectroscopic database to confirm the spectral types. A total of 243 M giants, 834 M dwarfs, and 14 C stars, namely 1091 objects, have been confirmed. A new "Value-added catalogue of late-type stars found in the Digitized First Byurakan Survey database; third edition" was generated (Gigoyan et al., 2025) (online available at J/MNRAS/539/223/catalog/).

In Figures 1 - 3, we present the DFBS low-resolution spectral shapes and consequently the Gaia DR3 spectra for confirmed M giant DFBS J035851.35+700544.9, for M dwarf DFBS J072034.43+445734.6, and for the CH giant, as illustrative examples.

3. Analysis

Figure 4 presents the observational Gaia absolute magnitude (M(G)) versus BP-RP color, or Hertzsprung-Russell Diagram-HRD) for all 1091 DFBS LTS. We have used the distance information derived from Gaia EDR3 by Brown et al. (2021) (CDS VizieR Catalogue I/352/gedr3dis).

Figure 5 presents the histogram of the Gaia DR3 G-wide band magnitude distribution of all 1091 new DFBS LTS.

4. Summary And Future Works

This new "Value-added catalogue of late-type stars found in the Digitized First Byurakan Survey Data Base: Third Edition" shows the potential of FBS. This catalogue lists a large number of completely new objects, which promise to significantly extend the census of faint M dwarfs, M giants, N-type Asymptotic Giant Branch (AGB) carbon stars, and CH-type giants at high Galactic latitudes.

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This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. This work has made use of data from the ESA mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC).

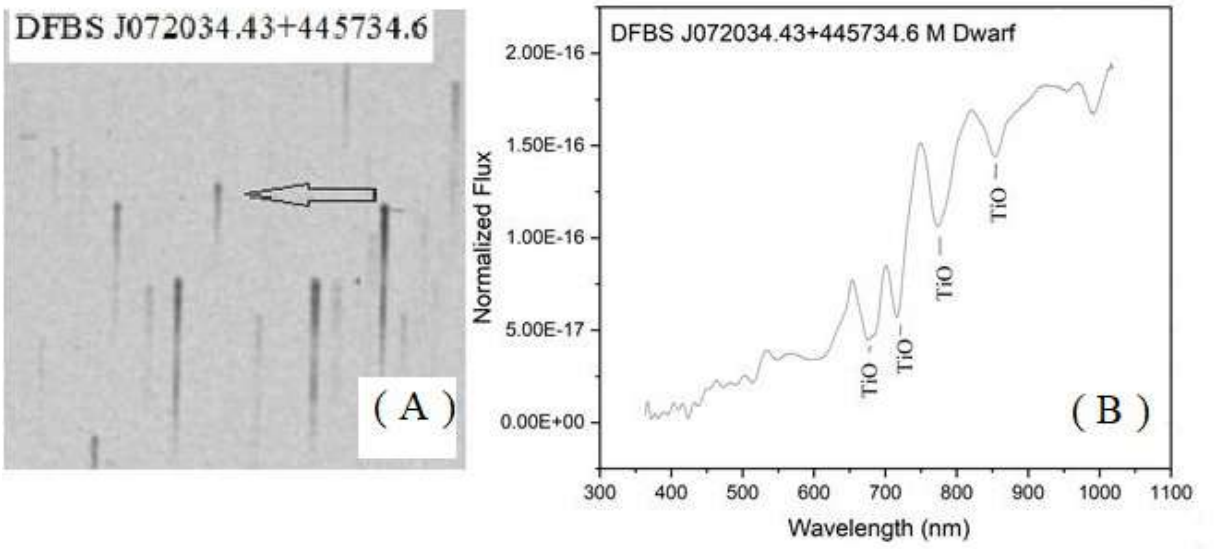

Figure 2. DFBS lr spectral shape (A) and Gaia DR3 BP/RP spectra for new confirmed M dwarf DFBS J072034.43+445734.6. (Gmag = 13.771, Teff = 3268 K, TIC Number is 407570734, R = 0.365 Rsun, M = 0.351 Msun, r = 46 pc).

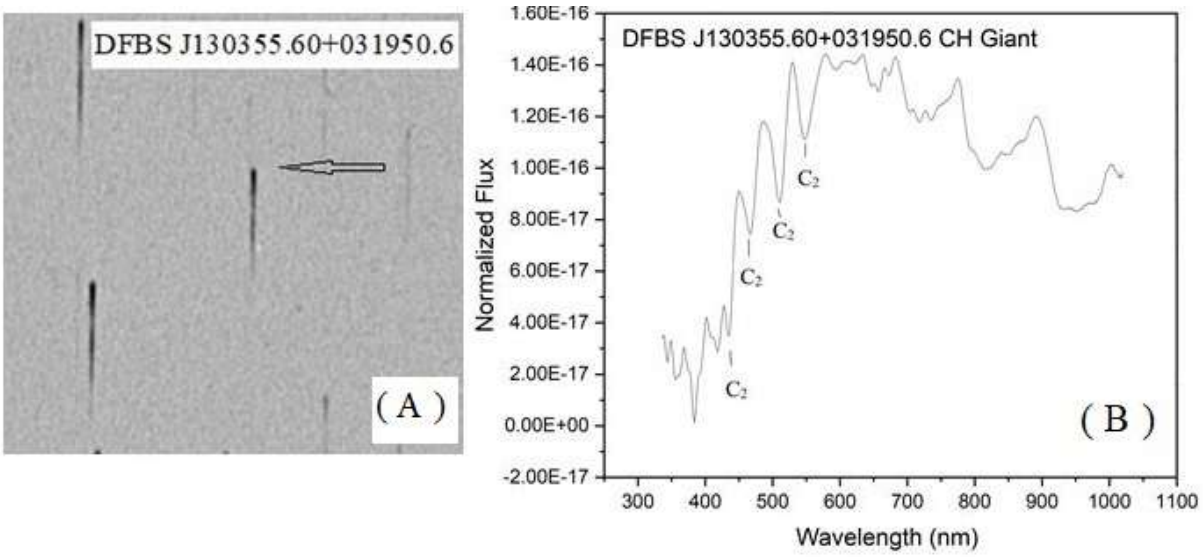

Figure 3. DFBS lr spectral shape (A) and Gaia DR3 BP/RP spectra for new confirmed CH giant DFBS J130355.60+031950.6 (TIC Number is 411255680, Gmag = 13.370, T_eff = 4569 K, R = 18.964 Rsun).

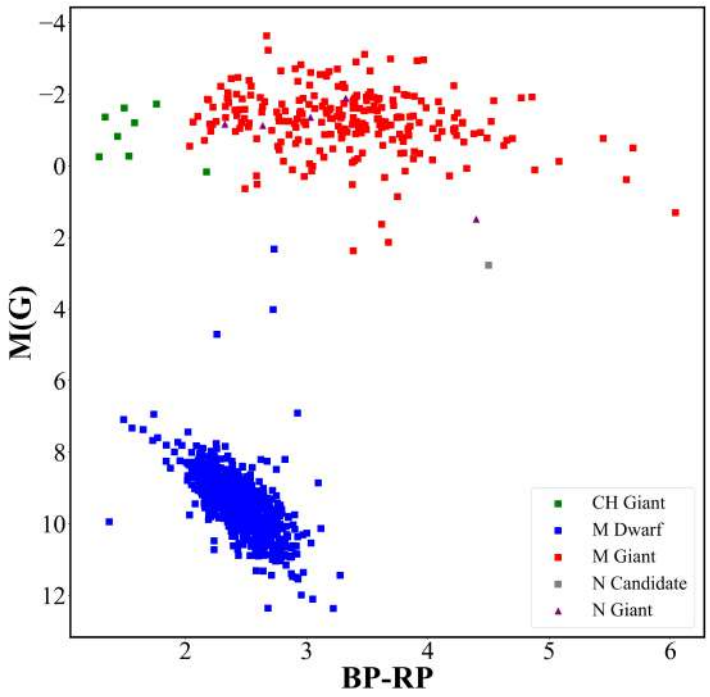

Figure 4. Gaia DR3 absolute magnitude M(G) versus BP-RP color for all 1091 new DFBS Late-Type stars.

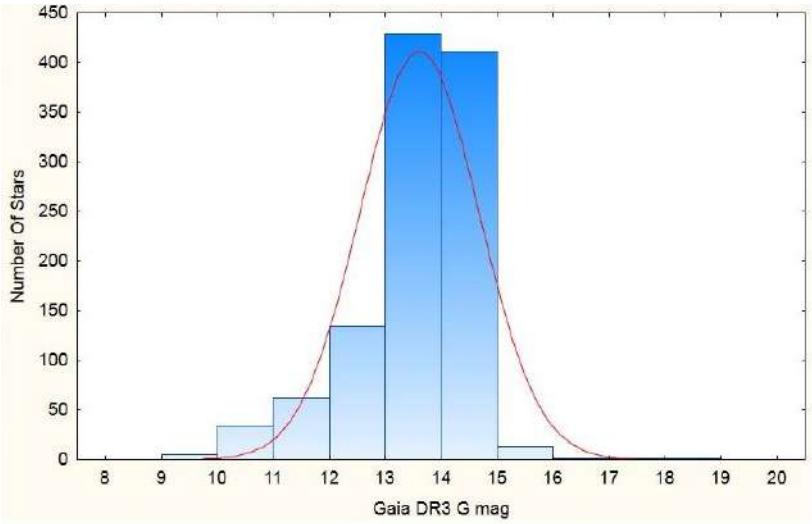

Figure 5. Histogram of the G-band magnitude distribution of all new 1091 DFBS LTS.

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