# New M dwarfs found in DFBS plates

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**Abstract**

In this paper we report about 100 new M dwarfs, confirmed in the DFBS database. The DFBS is the digitized version of the First Byurakan Survey (FBS, or Markarian survey). FBS plates have been used to search and study faint Late-Type Stars (LTS). The confirmations is based on Gaia DR3 BP/RP spectral database. In previous studies of the DFBS plates, these objects were presented as LTS candidates. TESS phased light curves for some of them shows flares. In SEDs of these objects the infrared excess is clearly visible.

***Keywords:*** *late-type -stars: M dwarfs, surveys: TESS and Gaia*

## 1. Introduction

The Digitized First Byurakan Survey (DFBS) is the digitized version of the First Byurakan Survey (FBS, or Markarian survey). This objective-prism survey was carried out in 1965-1980 by B.E.Markarian and his colleagues using the 1m Schmidt telescope of the Byurakan Astrophysical Observatory (Markarian et al., 1989). FBS low-resolution spectral plates have been used for a long time to search and study faint Late-Type Stars (LTS, M-type and C stars) at high Galactic latitudes (Gigoyan et al., 2019, 2024).

The M-type dwarfs occupy the lower third right-hand corner of the main sequence. They are a diverse bunch of objects that range in mass from a little over half that of the Sun down to around a thirteenth (approximately 0.075 - 0.5M$\odot$) its size (Stevenson, 2019). M-dwarf stars are most common stars, representing more than 75% of all stars within our Galaxy (Henry et al., 2006, 2018). They dominate the stellar populations by number, but have a effective temperature ($T_eff$) less than 4000K (Delfosse et al., 2000). M – type stars can easily be distinguished because of the titanium oxide (TiO) molecule absorption bands at 4584, 4762, 4954, 5167, 5500 and 6200 Å.

We present data for 100 newly found DFBS M dwarfs, confirmed in the Gaia Data Release 3 (DR3) low-resolution (lr) spectroscopic data base. This paper is structured as follows: Section 2 introduces the Gaia DR3 lr spectral data base, which is used to validate the spectral types of the DFBS LTS candidates. TESS observations and analysis of TESS light curves of FBS M dwarfs are presented in Section 3. Investigation of infrared emission from M dwarfs is presented in Section 4. We conclude with a short summary and an outlook in Section 5.

## 2. DFBS and Gaia DR3 low-resolution spectra

To classify LTS candidates, we use Gaia DR3 BP/RP lr spectroscopic database (Gaia Collaboration, Vallenari et al., 2023), which allows us to confirm the spectral types for candidates very easily. 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 molecules in the range 6500-7000 Å, 7000-7500 Å, and 8000-8500 Å.

Figure 1 presents the spectra of DFBS binary system of M dwarfs, which have low-resolution spectra in Gaia DR3 spectroscopic database. Gaia DR3 lr spectra of binary system are presented in Figure 2.

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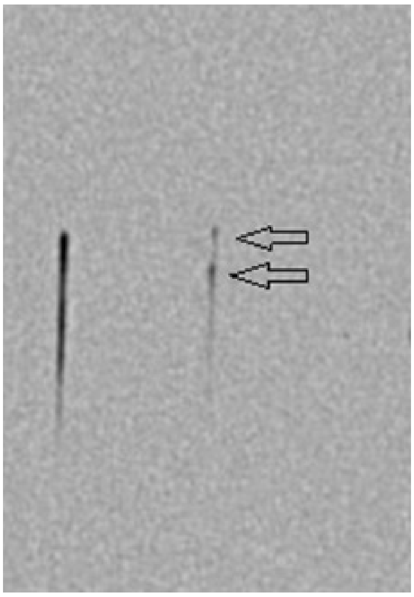

Figure 1. Low-resolution spectra of DFBS binary system of M dwarfs.

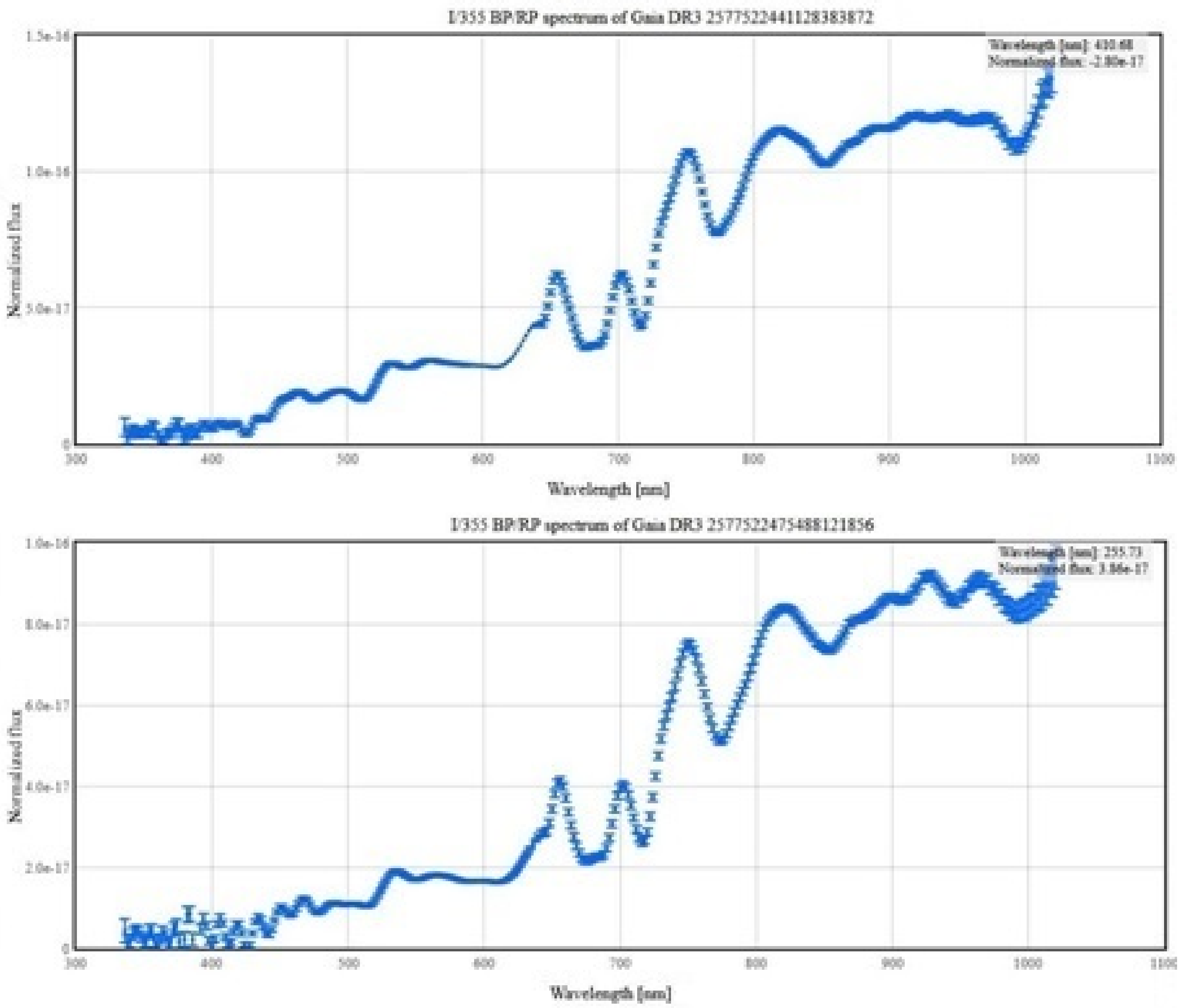


Figure 2. Gaia DR3 low-resolution spectra of DFBS binary system of M dwarfs.


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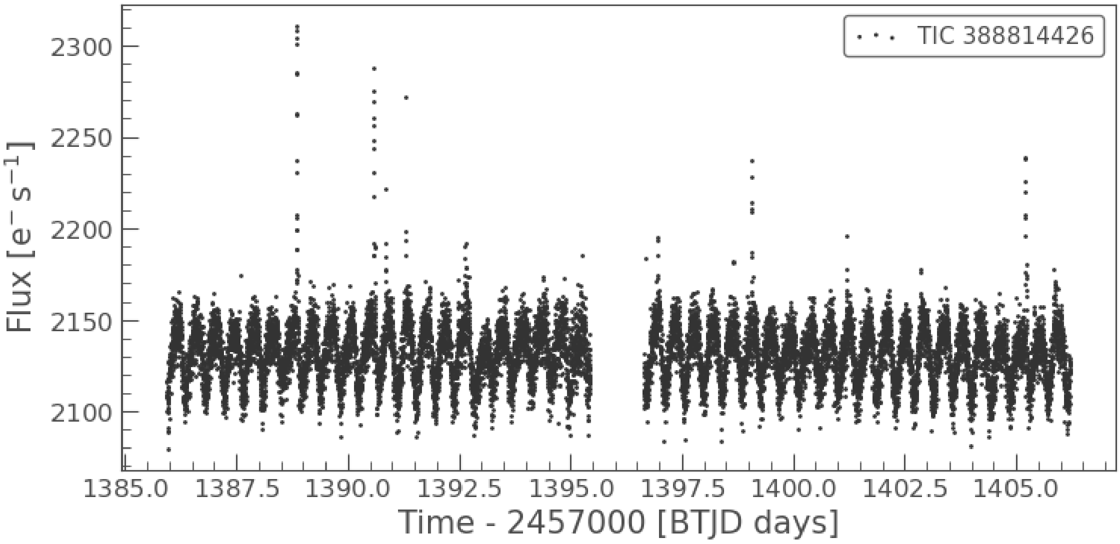


Figure 3. TESS phase-dependent light curve of new confirmed M dwarf with RA = $01^h13^m26.^s$ 8920 and DEC = $+00^d01^m07^s.706$.

## 3. TESS observations and analysis of TESS light curves of FBS M dwarfs

M dwarfs are favourable targets for transiting exoplanet surveys. NASA's Transiting Exoplanet Survey Satellite (TESS) is an allsky space-based mission designed to search for planets transiting around nearby M dwarfs (Ricker et al., 2014). Launched in 2018 April, it started regular science operation on 2018 July 25. Its observed $\sim 73\%$ of the sky across 26 sectors, each lasting 27.4 d and covering a $24^0 \times 96^0$ field of view. TESS observed a number of stars at 2-min cadence and collected full frame images (FFIs) every 30 min, covering the entire mission phase.

Some M-type dwarfs belong to a class of variable stars called UV Ceti stars. Strong magnetic fields and a fast rotation stir and heat plasma in their atmospheres, producing powerful flares. These flares brighten the stars by 1–3 magnitudes and generate powerful X-ray and radio bursts. Indeed, the X-ray and radio flares produced by these stars are over one hundred times as energetic as those on the Sun. It seems that these mice can occasionally roar. The precise mechanism by which these magnetic fields arise in the smallest stars is a little unclear, but it must involve some combination of star-wide convection and stellar rotation (Stevenson, 2019).

We downloaded the Presearch Data Conditioning Simple Aperture Photometry (PDC-SAP) light curves from the Mikulski Archive for Space Telescopes (https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html). We then used lightkurve (http://docs.lightkurve.org) to download the target pixel files (TPFs) and to analyse light curves for FBS M dwarfs monitored by TESS. TESS phase-dependent light curves show flares for many new M dwarfs. Figure 3 shows example of such flares in TESS light curve for new confirmed M dwarf with RA = $01^h13^m26^s.8920$ and DEC = $+00^d01^m07^s.706$

Figure 4 presents lr spectrum of Gaia DR3 for this object.

## 4. The infrared emission. Spectral energy distribution (SED).

Infra-Red emission from M dwarfs has been investigated in multiple studies. Extra flux in the IR range characterized the circumstellar dust which mark certain stages in the life of a planetary system (protoplanetary disc, and final stage is a debris disc, Luppe et al. (2020). Sgro & Song (2021) used *Gaia* DR2 and ALLWISE W3 and W4 passbands to search for M dwarfs with IR-excess, within 100 pc. Using a special SED fitting algorithm, Sgro & Song (2021) developed a photospheric model for each sampled star, determined its significance of excess (SOE), and discussed the nature of IR excess in more detail.

We examine visually the SEDs for all FBS M dwarfs to search for possible dusty discs signature around them. All these SEDs have been built and taken from the SIMBAD VizieR data base (access via https://vizier.unistra.fr/vizier/sed/) using the SED builder tool. The SED of M dwarf (RA = $01^h13^m26.^s$ 8920 and DEC = $+00^d01^m07^s.706$) with very clear IR-excess is shown in the Figures 5, where the excess IR radiation is clearly visible after 10 $\mu$m (in WISE W3 and W4 passbands). An IR excess emission is not


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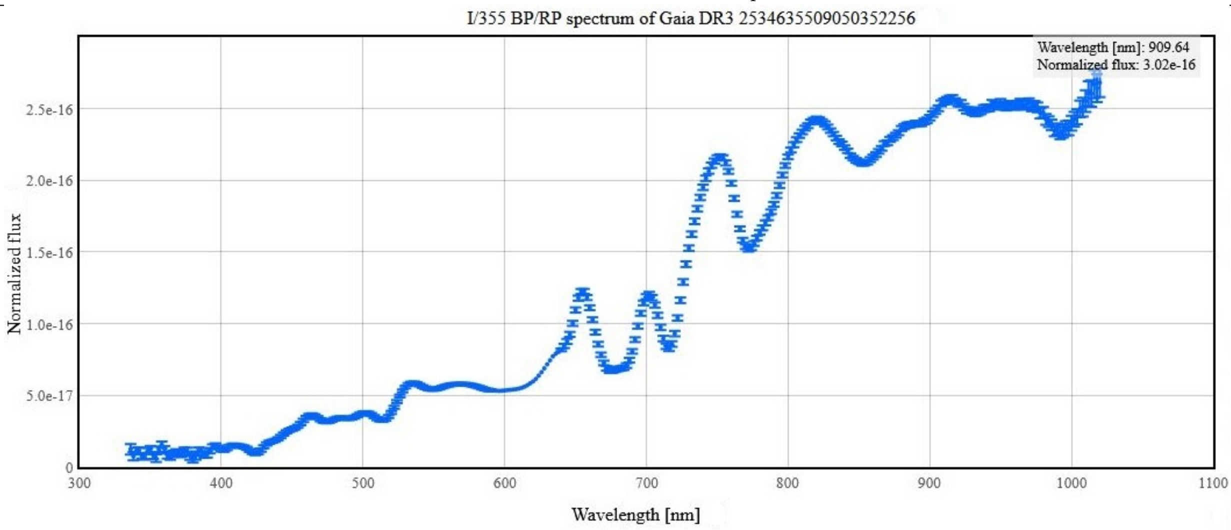


Figure 4. Gaia DR3 spectum of the new confirmed M dwarf with RA = $01^h13^m26^s.8920$ and DEC = $+00^d01^m07^s.706$.

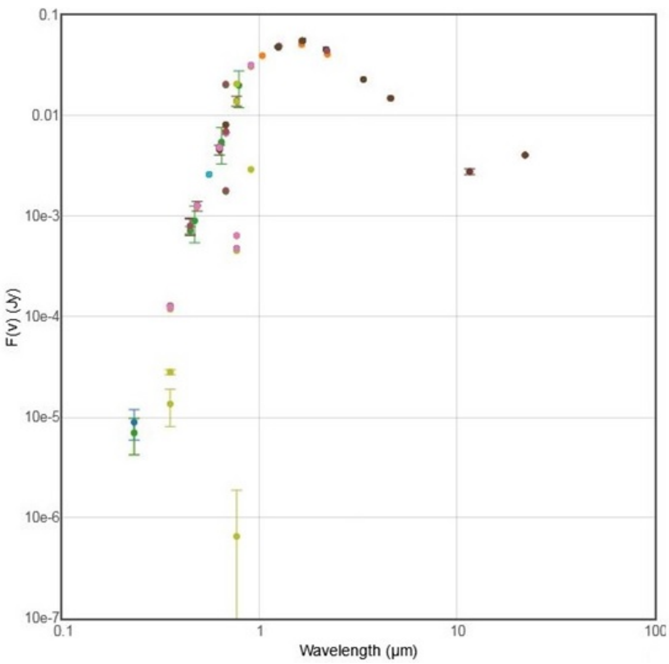


Figure 5. Gaia DR3 spectum of M dwarf with RA = $01^h13^m26^s.8920$ and DEC = $+00^d01^m07^s.706$.

obvious in the SEDs of the other FBS M dwarfs.

## 5. Conclusion

In this paper we inform a some amount of new M dwarfs, confirmed in the DFBS lr spectroscopic data base. Confirmation was made using Gaia DR3 BP/RP spectroscopic catalogue. TESS phase-dependent light curves show flares for many FBS M dwarfs. The SED of new confirmed M dwarf with RA = $01^h13^m26.^s$ 8920 and DEC = $+00^d01^m07^s.706$ shows clear IR-excess. The excess IR radiation is clearly visible after 10 $\mu$m (in WISE W3 and W4 passbands). An IR excess emission is not obvious in the SEDs of the other FBS M dwarfs.

The list of all spectroscopically confirmed DFBS M dwarfs, reported as a supplementary (value-added) catalogue to the second edition of the "Revised and Updated Catalogue of The First Byurakan Survey" will be presented in SIMBAD astronomical database very soon.


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