АСТРОФИЗИКА

TOM 62

НОЯБРЬ, 2019

ВЫПУСК 4

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NEW CARBON STARS CONFIRMED IN THE DIGITIZED FIRST BYURAKAN SURVEY DATABASE

1. *Introduction*. The spectroscopic plates of the First Byurakan Survey (FBS, also known as the Markarian Survey) were used to select late type stars (LTSs), type M and carbon (C) stars, at high galactic latitudes. The FBS is an objective prism, low resolution spectral survey that covers a 17.000 deg² area. It was performed with the Byurakan Astrophysical Observatory (BAO) 1 m Schmidt telescope, which was equipped with 1°.5 prism giving dispersion of 1800 Å /mm near H γ . The FBS was conducted originally to locate galaxies with ultraviolet excess. In total, 1515 galaxies were discovered [1].

Now the entire plate set has been digitized, leading to the Digitized First Byurakan Survey (DFBS) [2] (online at http://www.ia2-byurakan.oats.inaf.it/). Subsequently, all DFBS spectral plates were searched for LTSs using standard image analysis software (FITSView and SAOImage ds9). The advantage of using this software for selecting type M and C stars are described in paper [3]. "The Second Revised And Updated Catalogue of the First Byurakan Survey Late-Type Stars", with comprehensive data for 1471 new objects will become available very soon at CDS, VizieR, SIMBAD database [4]. C stars can be identified through the presence of the C2 molecular bands at 4737, 5165, and 5636 Å (N type C stars, Swan bands). Several objects can be distinguished by the titanium oxide (TiO) molecular absorption bands at 4584, 4762, 4954, 5167, 6200, and 6700 Å [4].

However, because our selection of LTSs on DFBS plates is not automatic (using machine learning algorithms), a list of the LTS candidates was noted also for further confirmation. These candidates are mainly faint objects close to the limit in each DFBS plate, or dot-like spectra showing only the reddest end of the continuum, where C_2 or TiO absorption bands are not visible.

In this paper we present confirmations for three FBS C star candidates. One of them we classify as a CH type giant and two others are N type asymptotic giant branch (AGB) C stars.

2. Spectroscopy. For three candidate stars, medium-resolution CCD spectra

K.S.GIGOYAN ET AL.

in the range 4000-7000 Å (resolution 5 Å) were obtained on 10/11 and 12/13 November 2018 at the BAO 2.6 m telescope. We used the SCORPIO spectrograph with grism No 600. Its detector is an EEV 42-40 CCD (2048×2048 pixel, 13.5 µm pixel size). Standard data reduction was carried out with the ESO MIDAS Software.

In Table 1, we list following quantities: column 1: FBS Number; column 2: the coordinates (RA. and Dec.) for J2000; from the STScI POSS2 R (red) (Digitized Sky Survey - https://archive.stsci.edu/cgi-bin/dss_form/), column 3: exposure time; column 4-6: 2MASS (Two Micron All - Sky Survey) J, H and

Table 1

FBS Coordinates (J2000) Exp. time J Η Κ Sp Other Number (in sec.) Association RA Dec mag mag mag +45°39'13".0 0017+453 00^h20^m03^s.44 CH 300 11.83 11.21 11.03 0340+419 03 43 38.02 +42 03 31.0 600 9.29 7.81 6.77 IRAS 03402+4154 Ν 0516+054 05 19 18.28 +05 29 03.3 600 9.60 7.97 6.66 Ν V675 Ori

DATA FOR NEW CONFIRMED FBS CARBON STARS



7000

644

4000

5000

Wavelength (Å)

6000

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Ks magnitudes (http://irsa.ipac.caltech.edu/2mass/); column 7: spectral type; and column 8: other association in SIMBAD database (http://simbad.u-strasbg.fr).

Fig.1 presents the BAO 2.6 m telescope spectra for three new confirmed C stars. We classify FBS 0017+453 as a CH type C star (presence of the strong G band of the CH molecule at 4300 Å), based on the classification criteria which are summarized in paper [5]. The remaining two objects are typical N type C stars. The spectrum for FBS 0340+419 in the range 3900-9100 Å is also available in LAMOST (Large Sky Area Multi-Object Fiber Spectroscopic Telescope) fourth Data Release (DR4) database (SIMBAD CDS VizieR catalog V/153; object number is LAMOST J034338.04+420331.0). But it is not included in the catalog of 2651 C stars by Yin-Bi et al. [6] from DR4, where for selection the authors used an efficient machine learning algorithm.

In Table 2 we present some important physical characteristics for the new confirmed C stars from the Gaia DR2 catalogue (CDS VizieR catalog I/345) [7]. We list the following parameters: column 1: the FBS Number; column 2: the Gaia DR2 name; column 3 and 4: Gaia DR2 G mag and BP mag; column 5: BP-RP mag (color index); column 6: effective temperature (T_{eff}) ; column 7: distance in pc (distances are available from the catalogue of Bailer Jones et al. [8], CDS VizieR catalogue I/347).

Table 2

| FBS Number | Gaia DR2 Name | G mag | BP mag | BP-RP mag | T _{eff} (K) | Dist. (pc) |
|------------|---------------------|-------|--------|-----------|----------------------|------------|
| 0017+453 | 391891305923876352 | 13.75 | 14.45 | 1.50 | 4423 | 8000 |
| 0340+419 | 237209708028168576 | 12.95 | 15.07 | 3.44 | 3300 | 4500 |
| 0516+054 | 3237482992663918848 | 14.09 | 16.38 | 3.61 | 3300 | 4100 |

SOME IMPORTANT GAIA DR2 DATA FOR NEW CONFIRMED FBS C STARS

3. Variability. In the Catalina Sky Survey (CSS), a phase dependent light curve is available only for FBS 0516+054 (online at http://nesssi.cacr.caltech.edu/ DataRelease/) [9], source number CSS _J051918.3+052902, $V_{\rm CSS} = 14.34$. The phase dependent light curves for objects FBS 0017+453 and FBS 0340+419 are available in the Northern Sky Variability Survey database [10] (NSVS at http://skydot.lanl.gov/nsvs/) with identifiers 3700789 and 4178094 respectively.

Fig.2 presents the CSS light curve for FBS 0516+054. The pulsation period can be estimated as 420 days, applying the VStar data visualization and analysis tool (http://www.aavso.org/). Applying the Whitelock et al. [11] revised period-luminosity (PL) relation:

K.S.GIGOYAN ET AL.

$$M(K) = -3.51 \times (\log P - 2.38) - 7.15, \tag{1}$$

we obtain M(K) = -8.0 and with K = 6.67, the distance can be estimated as r = 8.6 kpc (with a $A_{k} = 0.05$ mag from the NASA Extragalactic Database, http:// ned.ipac.caltec.edu, practically negligible). FBS 0516+054 is at $L = 196^{\circ}.9$, $B = -17^{\circ}.6$. If its distance is correct, it is very interesting, because the star is near the Galactic Anticenter ($L = 180^{\circ}$, $B = 0^{\circ}$), so its distance from the Galactic Center is nearly 17 kpc (adopting for the Sun r = 8.5 kpc).



Fig.2. Catalina Sky Survey phase dependent light curve for FBS 0516+054. The X axis shows the period in Julian Data and the Y axis shows the CSS V band magnitude.

It is very difficult to estimate the pulsation period for FBS 0340+419 because of the short baseline of NSVS [10].

4. *Conclusion*. BAO 2.6 m telescope spectra in the range $\lambda 4000-7000$ Å for three candidates selected on the DFBS plates confirm their C rich nature. One of them we classify as a CH type and two others as N type C stars. Some important physical physical characteristics for them are presented from the Gaia DR2 data base.

Acknowledgments. K.S.G. thanks CNRS, LATMOS, University of Versailles Saint Quentin en Yvelines, and LAM for supporting this study. This work was made possible by a research grant from the Armenian National Science and Education Fund (ANSEF) based in New York, USA.

Новые углеродные звезды из DFBS. Спектральные наблюдения в диапазоне λ 4000-7000Å для трех звезд, отобранных на DFBS пластинках как кандидаты, подтвердили их принадлежность к классу углеродных. Одна является СН-звездой, две остальные - углеродными звездами класса N. Некоторые

NOTES

важные физические характеристики для новых объектов приводятся из Gaia DR2 баз данных.

Ключевые слова: обзоры: углеродные звезды

| 24 апреля 2019 | | | |
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