АСТРОФИЗИКА

ТОМ 51 МАЙ, 2008 ВЫПУСК 2

LATE-TYPE STARS FOUND IN THE FBS. NEW CARBON STARS

K.S.GIGOYAN[1], D.ENGELS[2], N.MAURON[3], V.V.HAMBARYAN[4], C.ROSSI[5], R.GUALANDI[6]

Received 31 August 2007
Accepted 13 February 2008

We present new observations of seven late-type stars previously discovered in the First Byurakan Survey (FBS). These observations prove that they belong to the family of carbon (C) stars. 79 similar FBS C stars were previously known. The seven objects under analysis were presented in the FBS lists as M or C star candidates. Among the 7 objects, 6 objects are confirmed by low-resolution spectra of the Hamburg Quasar Objective-Prism Survey. We also present for 5 of them moderate-resolution spectra obtained at optical wavelengths with a spectrograph equipped with a CCD detector. Three objects can be classified as N-type C stars. One object is an early CH-type C star. Most likely, the star FBS 1339+117 belongs to the group of carbon dwarfs. We estimate distances of these seven new C stars either by using their red-band magnitudes, or by using their near-infrared 2MASS $J-K_s$ color and K_s-band magnitudes.

Key words: *surveys: stars: carbon: spectra*

1. *Introduction.* During the fourteen years 1989 to 2003, the First Byurakan Spectral Sky Survey (FBS) [1,2] was used to study low-resolution (LR) objective-prism spectra of many families of objects. In particular, the FBS material was used to select faint late-type stars. One of the goals was to clarify the nature of these objects at high Galactic latitudes. The FBS objective-prism survey was carried out by Markarian and associates [3] over the 1965-1980 period using the 1m Schmidt telescope of the Byurakan Astrophysical Observatory (BAO, Armenia). The survey covers nearly 17000 deg^2 of the Northern Sky segmented in 28 parallel zones. The limiting photographic magnitude is $17^m.0$-$17^m.5$. All FBS LR survey plates are now digitized (DFBS - Digitized First Byurakan Survey [4]) and online access is available at http://byurakan.phys.uniroma1.it/ at La Sapienza University, Roma (Italy). More details about the DFBS are given on site - http://www.aras.am/dfbs/. The large spectral range of the FBS ($\lambda 3400 - 6900$Å) is well suited to identify various types of objects. Due to the strong absorption bands, this is especially true for cool M-type and carbon (C) stars, including early R-type (or CH) objects and N-type objects. Information about the FBS and a description of the spectroscopic criteria that we used for selecting M-type and C-type stars - have been given in earlier papers [1,2]. The

systematic search for late-type stars permitted to discover nearly 900 new objects. Among them there are 79 confirmed N and R (or CH) -type C stars, 32 early R (or CH) -type star candidates and 8 very late M-type or N-type star candidates. The remaining objects are M-type stars.

The 40 stars with uncertain classification have the following spectral properties on the FBS LR spectral plates:

a) Very short spectra in the range $\lambda 6300 - 6900$Å (wedge-like) which are very similar to spectra of late M-subclasses or very late N-subtype C-stars, except that the TiO or C_2 molecule absorption bands are not visible. Such objects are presented in the FBS lists as late M or N-type star candidates.

b) Very faint spectra (in the range $\lambda 4000 - 6900$Å) that are very similar to early CH-type C star spectral flux distributions. The absorption bands of the C_2 molecule are not or only marginally visible, because the brightnesses are close to the detection limit. Such objects are presented as early R (or CH) C star candidates in the lists of FBS late-type stars.

In order to check the nature of the 40 candidates with these spectral properties but with uncertain classifications, in particular of the early CH star candidates, we extracted additional objective-prism spectra from the LR digitized spectral database of the Hamburg Observatory (Germany). This database includes the Hamburg Quasar Survey (HQS) and the Hamburg/ESO Survey (HES) databases. Both surveys (HQS and HES) are deeper than the FBS, with also better spectral resolution.

2. *HQS and HES surveys.* The Hamburg Sky Surveys made on Schmidt plates taken with objective-prisms consist of two complementary parts, which are the Northern Hamburg Quasar Survey (HQS) ($|b| > 20°$, $0° < \delta < +80°$) and the Southern Hamburg/ESO Survey - HES ($|b| > 30°$, $\delta < +2.5°$). The plates of the HQS were taken in the years 1985-1997 with the Calar Alto Schmidt telescope and contain spectra with seeing limited resolution of 45 Å at Hγ in the magnitude range $14^m.0 < B < 19^m.0$. The sky area covered by this survey is 13600 square degrees. The instrumental characteristics were: Kodak IIIa-J emulsion, 1°.7 prism, dispersion 1390 Å/mm near Hγ, spectral range $\lambda 3400 - 5400$Å. The southern plates were obtained with the ESO Schmidt telescope during the years 1990-1996. They have a spectral resolution of 15 Å at Hγ and contain usable spectra in the magnitude range $13^m.0 < B_J < 18^m.0$. Its sky area covers 6400 deg^2, and this southern survey was achieved with the Kodak IIIa-J emulsion, a 4° prism, a dispersion 450 Å/mm near Hγ, and a spectral range $\lambda 3200 - 5200$Å. The LR spectral plates for both (HQS and HES) surveys were scanned by the Hamburg PDS microdensitometer and online access to the digitized database is available on http://www.hs.uni-hamburg/hqs.html.

3. *New C stars confirmed.* No objective prism spectra could be retrieved for 8 of the candidates. For stars FBS 0658+400, FBS 0754+109, and FBS 0832-095 there are no HQS and HES fields. The LR spectrum of FBS 0301+008 is absent on the HQS plate. This object probably is a large-amplitude variable. In three cases (FBS 0230+008, FBS 0410+049 and FBS 0429+009), the spectrum most probably is blended with the spectra of a neighboring bright star on the HQS LR plate. Finally, for FBS 1640+701 the HQS LR spectrum is not usable because of a plate defect. Among the 32 candidates with HQS or HES spectra we could confirm six candidates as belonging to the group of C stars. In addition, follow-up medium-resolution CCD spectroscopy (see below) confirmed FBS 0754+109 as a C star (Table 1). These objects add to the 79 FBS C stars already known [5,6].

In Table 1, we list the following quantities. Column 1: FBS Number; column 2-5: photometric data from USNO-B1.0 [7] (http://cdsweb.u-strasbg.fr/viz-bin/VizieR?-source=I/284/); column 6-8: 2MASS (Two Micron All-Sky Survey) J, H and K_s near-infrared magnitudes (http://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-dd/); column 9: corresponding FBS lists, where the coordinates for J2000 and the suspected subtype for candidate objects are presented.

Table 1

THE USNO-B1.0 AND 2MASS PHOTOMETRIC DATA FOR NEW FBS C STARS

FBS Number	*B1* mag	*R1* mag	*B2* mag	*R2* mag	*J* mag	*H* mag	K_s mag	References
0018+213[1]	11.1	9.1	10.3	9.1	7.833	7.346	7.195	[2] R?
0158+095[2]		14.6	19.7	15.8	10.266	8.525	7.17	[1] M8-M9?
0324+236	16.3	13.3	16.1	13.5	11.240	10.418	10.080	[2] R?
0359+085	16.4	13.3	15.8	13.1	9.765	8.703	8.195	[1] M8-M9?
0754+109	14.7	12.6	14.5	12.8	11.196	10.639	10.451	[1] R?
0910+197[3]	16.7	11.4	15.5	11.5	9.030	7.932	7.368	[2] M7-M8?
1339+117	15.5	12.9	¶5.4	13.2	11.135	10.442	10.178	[1] R?

Notes to Table 1:

[1] The star FBS 0018+213 is very bright and on the HQS LR spectral plate the absorption bands of the C_2 molecule are not visible at wavelengths longer than λ4000Å due to saturation effects. This object is not included in the last (third) version of the Galactic Carbon Star Catalogue by Stephenson [8].

[2] FBS 0158+095 has an identification with the unknown IRAS source PSC 01582+0931 [9].

[3] The star FBS 0910+197 is also associated with the infrared source 2MASS J091331.86+193422.6 [10] and is known as a N-type AGB C star, selected by its $J - K_s$ color index. A spectrum is presented in paper [10] covering the region λ5700 – 6600Å.

Fig.1 presents a finding chart from the DSS2 R (red) (Digitized Sky Survey - http://skys.gsfc.nasa.gov/) and the corresponding HQS LR spec-

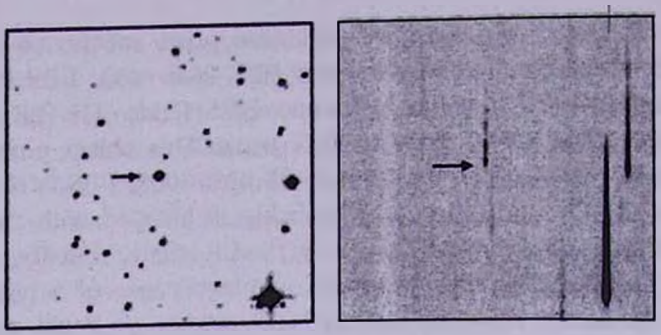

Fig.1. DSS2 *R* (Red) finding chart (left) and HQS objective-prism LR spectra (right) for the confirmed carbon star FBS 0324+236. On the HQS LR spectrum the absorption bands of C_2 molecule are very well expressed. Both fields are 5' x 5'.

trum for FBS 0324+236. The DSS finding charts for the remaining objects from Table 1 are presented in papers [1,2].

4. *Observations.* Follow-up moderate-resolution CCD spectra for five confirmed objects were obtained at the 1.83m Cima-Ekar telescope of the Padova (Italy) Astronomical Observatory (equipped with the Asiago Faint Objects Spectrometer and Camera - AFOSC, 1024 x 1024 pix CCD) and with the 1.52m Cassini telescope of the Bologna (Italy) Astronomical Observatory at Loiano (equipped with the Bologna Faint Object Spectrometer and Camera - BFOSC, 1300 x 1340 pix EEV P129915 CCD). Photometric observations have been obtained with AFOSC and BFOSC in the R-band on the same dates as for the spectra. All the spectroscopic and photometric data were reduced by means of standard IRAF[1] procedures. For these five stars Table 2 presents the journal of spectroscopic observations, the spectral class determined from the spectra and the *R*-band magnitudes. The spectra are shown in Fig.2 and 3 where in the *Y*-axis we plotted relative fluxes, corrected for the atmospheric extinction. The correction for the instrumental response was also applied.

Three objects (FBS 0158+095, FBS 0359+085 and FBS 0910+197) are

Table 2

JOURNAL OF OBSERVATIONS FOR NEW FBS C STARS

Star FBS	Date of observations	Telescope	Res. (Å/pix)	Spectral Range (Å)	R (red) mag	Sp. Class
0158+095	11.XI. 2006	1.83m-Asiago	4.99	3500-7800	14.40 ± 0.10	N
0359+085	26.XI. 2006	-"-	-"-		12.86 ± 0.05	N
0910+197	11.II. 2007	1.52m-Loiano	3.90	3940-8500	11.73 ± 0.01	N
0754+109	23.II. 2007	-"-	-"-	-"-	12.70 ± 0.02	CH
1339+117	22.III. 2007	-"-	-"-	-"-	13.18 ± 0.01	CH

[1] IRAF is distributed the NOAO which is operated by AURA under contract with NFS.

N-type C stars, while the spectra of FBS 0754+109 and FBS 1339+117 are typical for early CH-type carbon stars. The absorption G-band (bandhead at λ4315Å) of the CH-molecule is present in the spectrum of FBS 0754+197

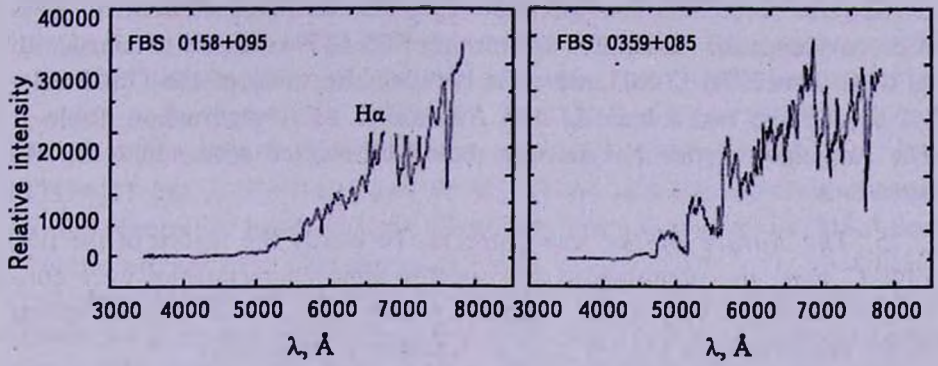

Fig.2. The 1.83m Asiago telescope spectra for FBS 0158+095 and FBS 0359+085, covering the wavelength range 3500-7800 Å.

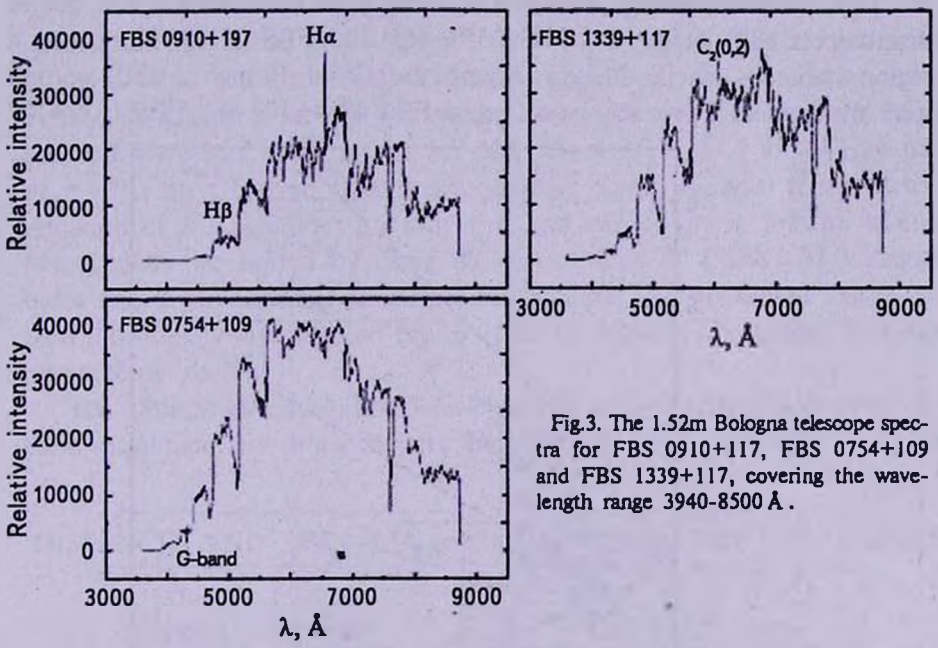

Fig.3. The 1.52m Bologna telescope spectra for FBS 0910+117, FBS 0754+109 and FBS 1339+117, covering the wavelength range 3940-8500 Å.

(in the spectrum of FBS 1339+117 it is very weak). Also, the Hα and Hβ emission lines in the spectra of FBS 0158+095 and FBS 0910+197 are indicators for periodic brightness changes and /or mass loss, i.e. they belong to the group of Carbon Mira Variables [11].

In fact, considering the *R* magnitudes for all stars in Table 1, a strong indication of variability is already obvious at least for FBS 0158+095, for which *R1* and *R2* differ by $1^m.2$, much more than the magnitude differences

of all other stars in the sample. For this star we obtained from the AFOSC photometry $R = 14^m.40 \pm 0^m.1$. The other 16 stars present in the field were found to agree with the GSC2 [12] values to within 0.15 mag. Because the GSC2 gives $R = 15^m.83$ for FBS 0158+095, our AFOSC measurement gives strong evidence for variability. Concerning FBS 0359+085, we obtained with AFOSC $R = 12^m.86 \pm 0^m.05$, which is between the value of the GSC2 ($R = 12^m.6$) and the two values *R1* and *R2* around $13^m.1$ reported in Table 1. The variability of this N-type star should be studied with additional observations.

5. *The nature of the new objects.* To clarify the nature of the new FBS C stars, the photometric and spectroscopic characteristics were considered. They are very useful, mainly for early-type carbon stars, as giant/dwarf discriminators [13,14] (i.e. as luminosity indicators).

The USNO-B1.0 [7] catalog gives non-detectable proper motions for all objects in Table 1. We considered 2MASS JHK_s colors (similar to papers [15-17]) as a near-infrared photometric dwarf/giant discriminator and found that objects FBS 0158+095, FBS 0359+085 and FBS 0910+197 occupy a region, where Galactic N-type Asymptotic Giant Branch (AGB) carbon stars are located. Two early-type C stars FBS 0754+109 and FBS 1339+117

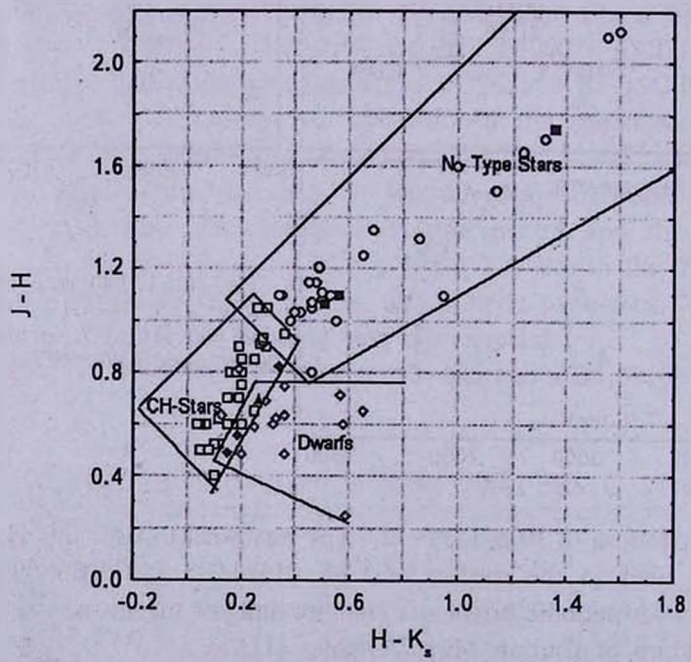

Fig.4. 2MASS $J - H$ and $H - K_s$ two-color diagram for carbon stars. Open circles are N-stars known, open squares are known CH-giant stars, open inclined squares - known carbon dwarfs (dC), filled squares and filled inclined squares are consequently new N-type and CH-type FBS stars, filled triangle presents the position of FBS 1339+117 on diagram. The classification of known objects are based on General Catalog Of Galactic Carbon Stars [8] data.

have small JHK_S colors, and they are located close to the borderline between giants and dwarfs (see Fig.4 of the present paper, also similar diagrams presented in papers [15-17] for more details). The spectrum of FBS 0754+109 shows a well expressed absorption G-band of the CH-molecule, allowing to classify this star as CH-giant. Only the star FBS 1339+117 is located in a region, where carbon dwarfs (dC) are found. All known carbon dwarfs have anomalous *JHK* infrared colors ($J-H<0.75$ and $H-K>0.25$) and are discussed in more detail in the papers [13,14]. FBS 1339+117 has $J-H=0.693$ and $H-K_S=0.264$ and the spectrum shows a strong absorption band of $C_2(0, 2)$ of the Swan system at λ6191Å. Both features are common characteristics for all carbon dwarfs [13]. Most likely, this object belongs to the group of carbon dwarfs, although the USNO-B1.0 catalogue gives zero proper motion for this star (we refer to paper Green et al. [13], that not all dwarf C stars will have detectable proper motions). This object deserves more detailed investigations in the future.

6. *Distances and luminosities.* We estimate the distances and luminosities for the objects in Table 1 in two ways. First, we use the calibration of the *K*-band absolute magnitudes as a function of the $J-K$ color index derived by Totten et al. [17] for carbon stars. The second estimate is based on methods described in papers [17-20], where $M_R=-3^m.5$ for N-type and $M_R=-2^m.5$ for CH-type C stars are adopted. Since we have recent determination of *R*-magnitudes for only five stars out of seven, for the sake of homogeneity we started by using the mean value of USNO-B1.0 magnitudes called *R1* and *R2*, presented in Table 1. The discrepant values are then individually discussed on the basis of the distances computed from our photometric data.

The distance estimates, based on both methods, the 2MASS absolute K_S-band magnitude and other data are presented in Table 3. In this Table, the

Table 3

DISTANCES AND $M(K_S)$ - MAGNITUDES FOR SEVEN FBS C STARS

FBS Number	d_R (kpc)	d_{J-Ks} (kpc)	Z (kpc)	$M(K_S)$ (mag)
0018+213	2.0	1.5	-0.96	-3.68
0158+095	55.0	15.8	-11.90	-8.80
0324+236	24.0	21.4	-10.00	-6.56
0359+085	21.9	15.0	-7.50	-7.68
0754+109	11.2	9.5	+3.16	-4.43
0910+197	10.0	11.1	+7.12	-7.85
1339+117	13.2	15.0	+14.10	-5.70

Note to Table 3: the quantities were estimated with the assumption that no interstellar or circumstellar extinction is present

distances determined by the above described methods are presented for comparison, together with other data. In Table 3 the columns have the following meaning: Column 1: running FBS number of stars (as in Table 1); column 2: the distance estimate, based on the R-magnitude (d_R); column 3: distance estimate, based on the 2MASS $J-K_S$ color index (d_{J-K}); column 4: height (Z) above or below Galactic plane (corresponding to d_{J-K}); column 5: the 2MASS K_S-band absolute magnitude, derived for each object as a function of $J-K_S$ color index [17].

The absolute K_S-band magnitudes, derived for the seven new FBS C stars, are typical for N and CH-type Galactic carbon stars [21]. For FBS 1339+117 an alternative distance $D \sim 60$ pc is possible, if this object is a dwarf carbon star, and adopting a K-band absolute magnitude $M_K = +6^m.3$ for carbon dwarfs [6].

For FBS 0359+085, the distances determined by the above noted methods are deviating, but this is still acceptable given the uncertainties in the photometry. A larger deviation is found between the distances obtained from the two methods for FBS 0158+095, similarly to the situation for FBS 1502+395 [5]. Most probably, FBS 0158+095 and also FBS 0359+085 are long-period, large-amplitude Mira-type variables, such as YY Tri, IRAS 07454-7112, CQ Pyx and IRAS 18248-0839 [22,23]. In addition, the large infrared color indexes ($J-K_S = 3^m.1$ and $K-[12] = 4^m.43$) for FBS 0158+095 can be considered as a evidence for a dense circumstellar envelope surrounding this object and places FBS 0158+095 in JHK_S two-color diagrams (see Fig.4, and similar diagrams in papers [15-17]) in a region where extremely red, dust-enshrouded and mass-losing Carbon-rich Miras are located. An approximate mass loss rate can be estimated as $\sim 10^{-6}\, M\odot$/yr assuming that the star is surrounded by a circumstellar shell and using relations between infrared colors and mass loss rates for Galactic carbon Miras [24]. This can explain why the distance based on the R-band magnitude is so large. For example, if one assumes a circumstellar extinction of $A_R = 2^m.0$ in the red-band, then one obtains (with $R = 15^m.2$ and $M(R) = -3^m.5$) a distance of 22 kpc, and this distance would be even smaller (15 kpc) if one adopts $R = 14^m.4$ from the Asiago photometry. Near-infrared monitoring (particularly in the K-band) is needed to determine their period and the absolute K-band ($M(K)$) magnitude for the above noted two objects.

7. *Concluding remarks.* We confirm the belonging to the group of carbon stars for seven additional objects, detected on the FBS survey plates. This brings the total number of these objects to 86. 6 C stars have been confirmed by considering their spectra on the Hamburg/Quasar Survey low-resolution objective-prism digitized database. We have also acquired follow-up slit CCD spectroscopy for 5 of them, revealing 3 N-type stars and two

objects with spectra, which are typical for early-type carbon stars. One of them FBS 0754+109 is a CH-giant and the second object FBS 1339+117, most likely is a dwarf carbon star previously not recognized. The distances and absolute K_s-band luminosities are estimated for the new confirmed objects. The distances have been determined by two methods and are in general in good agreement, although further observations and analyses are needed for the two objects FBS 0158+095 and FBS 0359+085.

For the future we planned a coordinated optical and near-infrared monitoring campaign for a selected sample of stars. If possible, infrared spectra will be taken in addition. A better estimate of luminosities and distances would be obtained from such a program. With the period - luminosity relation for C-Miras [25], this would allow to determine distances and mean absolute K-band ($M(K)$) magnitudes.

Acknowledgements. K.S.Gigoyan would like to thank DAAD (Deutscher Akademischer Austausch Dienst) for Grant A/06/33042, which made possible a research stay at the Hamburger Sternwarte. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, and also of the Two Micron All-Sky Survey database, which is a joint project of the University Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology. The University La Sapienza partially supported the project with funds from MIUR. The authors thank the Bologna and Padova observatories for the logistic support and the technical assistance during the observations.

[1] V.A.Ambartsumian Byurakan Astrophysical Observatory, Armenia, e-mail: kgigoyan@bao.sci.am
[2] Hamburger Sternwarte, Germany, e-mail: dengels@hs.uni-hamburg.de
[3] Groupe d'Astrophysique, CNRS & University de Montpellier, France, e-mail: mauron@kevin.graal.univ-montp2.fr
[4] Astrophysicalisces Institut, Universität Jena, Germany, e-mail: vvh@astro.uni-jena.de
[5] Universita di Roma "La Sapienza", Italy, e-mail: Corinne.Rossi@roma1.infn.it
[6] INAF, Osservatorio Astronomico Bologna, Italy, e-mail: Roberto.gualandi@oabo.inaf.it

ЗВЕЗДЫ ПОЗДНИХ СПЕКТРАЛЬНЫХ КЛАССОВ ИЗ ОБЗОРА FBS. НОВЫЕ УГЛЕРОДНЫЕ ЗВЕЗДЫ

К.С.ГИГОЯН[1], Д.ЭНГЕЛЬС[2], Н.МАУРОН[3], В.В.АМБАРЯН[4], К.РОССИ[5], Р.ГУАЛАНДИ[6]

Приводятся новые данные для семи звезд поздних спектральных классов, выявленных на пластинках обзора FBS. Эти объекты принадлежат к группе углеродных (С) звезд, в дополнение к семидесяти девяти звездам этого класса, определенным раньше. Исследуемые звезды приведены в FBS списках как кандидаты в М и С-звезды. Шесть объектов были определены как С-звезды после просмотра их низкодисперсионных спектров на объектив-призменных пластинках Гамбург - Обзора Квазаров (HQS). Приводятся CCD спектры для пяти звезд. Три из них можно классифицировать как С-звезды N-типа, а одну как звезду CH-типа. Вероятно, объект FBS 1339+117 принадлежит к группе углеродных карликов. Используя данные фотометрии в красных лучах, а также $J-K_s$ показатели цветов из обзора 2MASS, нами оценены расстояния до этих объектов.

Ключевые слова: *звезды: углеродные: спектры*

REFERENCES

1. *K.S.Gigoyan, H.V.Abrahamyan, M.Azzopardi, D.Russeil*, Astrofizika, **45**, 397, 2002.
2. *K.S.Gigoyan, H.V.Abrahamyan, M.Azzopardi et al.*, Astrofizika, **46**, 577, 2003.
3. *B.E.Markarian, V.A.Lipovetski, J.A.Stepanian*, Astrofizika, **17**, 619, 1981.
4. *A.M.Mickaelian, R.Nesci, C.Rossi et al.*, Astron. Astrophys., **464**, 1177, 2007.
5. *K.S.Gigoyan, N.Mauron, M.Azzopardi et al.*, Astron. Astrophys., **371**, 560, 2001.
6. *N.Mauron, K.S.Gigoyan, T.R.Kendall*, Astron. Astrophys., **463**, 969, 2007.
7. *D.Monet, S.E.Levine, B.Canzian et al.*, Astron. J., **125**, 984, 2003.
8. *A.Alksnis, A.Balklavs, U.Dzervitis et al.*, Baltic Astronomy, **10**, 1, 2001.
9. IRAS 1988, Joint IRAS Science Working Group. Infrared Astronomical Catalogs, The Point Source Catalog. Version 2.0, NASA RP-1190.
10. *N.Mauron, M.Azzopardi, K.Gigoyan, T.R.Kendall*, Astron. Astrophys., **418**, 77, 2004.
11. *Z.Alksne, A.Alksnis, U.Dzervitis*, "Properties Of Galactic Carbon Stars" Orbit Book Company, Malabar, Florida, 1991.
12. The Guide Star Catalogue, Version 2.3.2., Space Telescope Science Institute

(STScI) and Osservatorio Astronomico di Torino (2006) - http://vizir.u-strasbg.fr/viz-bin/VizieR?-source=I/305
13. *P.J.Green, B.Margon, S.F.Andersen, D.J.MacConnell*, Astron. Astrophys., **400**, 659, 1992.
14. *B.E.Westerlund, M.Azzopardi, J.Bresacher, E.Rebeirot*, Astron. Astrophys., **303**, 107, 1995.
15. *J.Liebert, R.M.Cutri, B.Nelson et al.*, Publ. Astron. Soc. Pacif., **112**, 1315, 2000.
16. *P.J.Lowrance, J.D.Kirkpatrick, I.N.Reid et al.*, Astrophys. J., **584**, L95, 2003.
17. *E.J.Totten, M.J.Irwin, P.Whitelock*, Mon. Notic. Roy. Astron. Soc., **314**, 630, 2000.
18. *E.J.Totten, M.J.Irwin*, Mon. Notic. Roy. Astron. Soc., **294**, 1, 1998.
19. *R.A.Downes, B.Margon, S.F.Anderson et al.*, Astron. J., **127**, 2838, 2004.
20. *N.Mauron, T.R.Kendall, K.Gigoyan*, Astron. Astrophys., **438**, 867, 2005.
21. *G.Wallerstein, G.R.Knapp*, Ann. Rev. Astron. Astrophys., **36**, 369, 1998.
22. *P.A.Whitelock, M.W.Feast, F.Marang, M.A.T.Groenewegen*, Mon. Notic. Roy. Astron. Soc., **369**, 751, 2006.
23. *F.Kerschbaum, M.A.T.Groenewegen, C.Lazaro*, Astron. Astrophys., **460**, 539, 2006.
24. *T.Le Bertre, J.M.Winters*, Astron. Astrophys., **334**, 173, 1998.
25. *M.A.T.Groenewegen, P.A.Whitelock*, Mon. Notic. Roy. Astron. Soc., **281**, 1347, 1996.