

NOTES

NEW CH CARBON STARS FOUND IN THE DFBS

1. *Introduction.* In this paper, we discuss the nature of three new carbon (C) stars discovered in the Digitized First Byurakan Survey (DFBS) [1] (DFBS is available online at <http://aras.am/Dfbs/dfbs/html/>, also at <http://ia2.oats.inaf.it/>). The three stars show early-type spectra in the DFBS. To better characterize these objects, medium-resolution CCD spectra were obtained. These stars show spectral features typical to CH-giants. 2MASS (Two Micron All Sky Survey [2], online at <http://irsa.ipac.caltech.edu/Missions/2mass.html/>), *JHK* Near-Infrared (NIR) photometry, and some other data for these objects are presented in paper[1], where we checked their possible proper motion in modern optical multi-color and multi-epoch databases. From NIR photometry, we derive effective temperatures. The light curves from the Catalina Sky Survey database (CSS) [3] (online at <http://nesssi.cacr.caltech.edu/DataRelease/>) were considered also for these objects.

2.1. *Optical Spectroscopy.* Moderate-resolution CCD spectra for new C stars were obtained on 27/28 June 2016 with the 2.6 m telescope of the Byurakan Astrophysical Observatory (BAO, Armenia) equipped with the SCORPIO spectrograph and using the Grism No 600 (spectral range $\lambda 4200 \div 6750 \text{ \AA}$, resolution $\sim 10 \text{ \AA}$) and the CCD detector TK 1024 \times 1024 (pixel size 24 $\mu\text{m} \times 24\mu\text{m}$). Standard data reduction was carried out with ESO-MIDAS common software.

Fig.1 presents the spectra for the 3 DFBS early-type C stars obtained with the BAO 2.6 m telescope where absorption bands of C₂ molecule Swan appear clearly.

2.2. *Temperatures From Photometric Data.* Determination of the effective temperatures T_{eff} is based on NIR color indices. To estimate T_{eff} for these 3 new DFBS C stars (also for 66 FBS early type C stars in paper [4]) we used an empirical relation between T_{eff} and the *J-K* color obtained by Bessel et al. [5];

$$T_{\text{eff}} = 7070 / [(J - K) + 0.88]. \quad (1)$$

All 3 stars can be considered nonvariable in the CSS variability database [3], which is a characteristic features mainly for early-type C stars [6].

In Table 1, we list the following quantities: Column 1: DFBS Number [1];

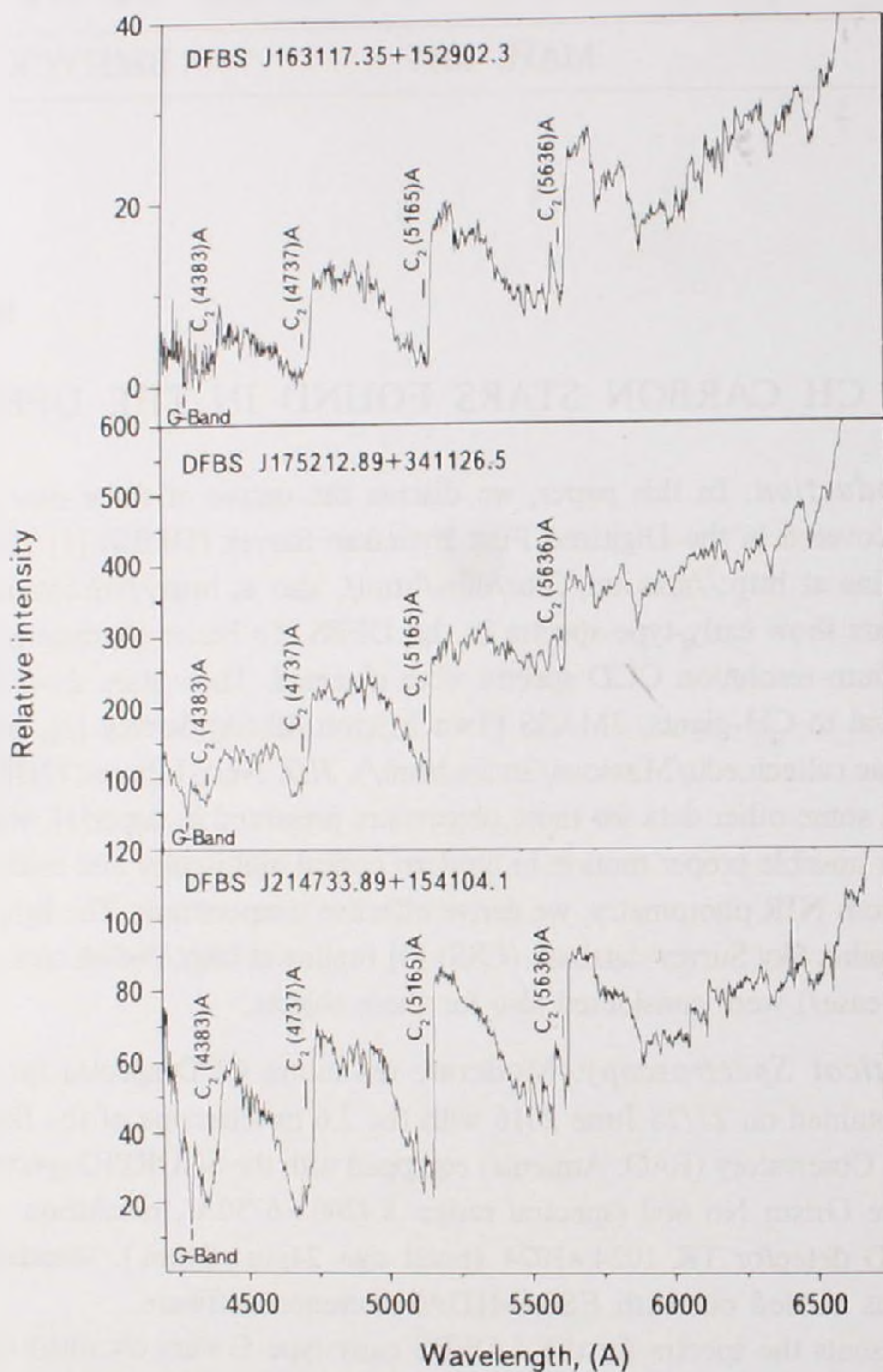


Fig.1. 2.6 m BAO telescope spectra for 3 CH-type carbon stars in the range $\lambda 4200 \div 6750 \text{ \AA}$. The absorption band heads of the C_2 molecule and G band of the CH molecule are indicated. The Y-axis is intensity in relative units.

column 2: exposure time for each spectrum (in seconds); column 3: CSS associations; column 4: Guide Star Catalogue V magnitudes (version 2.3.2, CDS Catalogue I/305); column 5: effective temperatures (with accuracy of about 250°K [5]) estimated by the method indicated above; column 6 \div 9 : photometric data (in mag.) from USNO-B1.0 [7] (CDS Catalogue I/284).

Table 1

DATA FOR 3 NEW DFBS EARLY-TYPE C STARS

DFBS Number [1]	Exp. T.	CSS Association	V	T_{eff} (°K)	B1	R1	B2	R2
J163117.35+152902.3	600	J163117.3+152902	14.47	3600	16.78	13.91	15.66	13.99
J175212.89+341126.5	300	J175212.9+311126	12.67	3990	14.64	12.59	14.06	12.56
J214733.89+154104.1	600	J214733.9+154103	13.98	4380	15.10	13.10	15.11	13.35

2.3. *Spectral Characteristics.* Spectra of the three new objects are compared with the "Moderate-Resolution Spectral Atlas of Carbon Stars" by Barnbaum et al. [8]. As we can see, in spectra of all 3 objects, the absorption bands of C_2 molecule (Swan systems [6]) are very strong and show characteristics of early-type C stars. Moreover, they show also the very intense G-band of the CH molecule at $\lambda 4300 \text{ \AA}$ (with the secondary P branch head at $\lambda 4342 \text{ \AA}$) which is the most useful indicator for CH stars. The presence of intense Ba II line at $\lambda 4554 \text{ \AA}$ is one of the important distinguishing characteristics for CH stars spectra [6].

3. *Absolute Magnitudes.* To estimate the absolute magnitudes for C stars a variety of methods were used. These is very difficult for individual objects, moreover, if they are early-subtypes and are not members of multiple systems. For late N-type stars which show periodic change of brightness the Period-Luminosity (PL) relations is applicable [1]. Adopting for CH giants $M_R = -2.5$ [9] and using USNO-B1.0 catalogue R1 and R2 mean values, the resulting distances can be estimated consequently 19, 10, and 14 kpc from the Sun for the objects in Table 1, i.e. they belong to the Halo of our Galaxy. It is important to note that distances are of the the same order if we use the GSC V magnitudes and adopt $M_V = -1.8$ for CH giants [8].

4. *Discussion And Conclusion.* Moderate-resolution CCD spectra in range $\lambda 4200 \div 6750 \text{ \AA}$ are presented for three new early-type C stars found in the DFBS database. They show CH star characteristics. 2MASS J - H and H - K NIR colors [1] are typical for C giants. These objects are known as Population II giants [6], but additional investigations, particularly high accurate radial velocity measurements are need to clarify the nature of these objects as in the Halo.

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Новые CH звезды, обнаруженные в DFBS. ПЗС спектры со средней дисперсией в области длин волн $\lambda 4200 \div 6750 \text{ \AA}$ получены для трех

новых углеродных C звезд ранних подклассов, выявленных на оцифрованных пластинках Первого Бюраканского Спектрального Обзора неба (DFBS). Объекты классифицированы как CH-звезды. Определены расстояния от Солнца, используя фотометрические данные в полосе R.

Ключевые слова: *Углеродные звезды: CH-звезды ранних подклассов*

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