SPECTRAL INVESTIGATION OF FIELD BLUE STRAGGLERS

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ABSTRACT. Field blue stragglers are counterparts of cluster blue stragglers. They were selected by Olsen in base of specific Strömgren indices among bright metal-deficient early F dwarfs.

For some stars from this list, the high-resolution and high S/N CCD spectra were obtained. Synthetic spectrum technique was applied for the specification of rotational velocities and chemical composition of program stars. Special attention was payed on FBS with high rotation and broad shallow lines with aim of comparison of their chemical abundances and abundances of λ Bootis type stars calculated with the same methodics. In general, 18 chemical elements were investigated. All metals show moderate deficiency. Most of the stars show normal abundance of sodium. With the exception of HD35863 the "normal" lithium abundance also was found in HD27523, HD45042 and HD88923.

Main question was "What is FBS?" We discussed three hypothesis that could be applied for explanation of their nature:
1) they are really blue stragglers with prolonged evolution;
2) they are normal stars wich were born in metal-deficient medium;
3) they are an extention of λ Boo stars towards lower temperature.

Key words: Stars: abundances; stars: blue stragglers.

1. Introduction

Blue straggler stars (BSs) are found: in open clusters of all ages (Population I, young disk, old disk), in globular clusters (Population II, halo), in the galactic field and in the dwarf galaxies. BSs lie to the left and above the turn-off point in the color-magnitude diagrams. Turnoff the region where normal single stars already have evolved away from the main sequence. BSs which belong to globular clusters are too faint for high-dispersion spectroscopy.

To find comparatively bright counterparts of these BSs Bond and MacConnell (1971) and Carney and Peterson (1981) looked for among the nearby Population II stars, because there is no obvious way to distinguish Population I BSs from the common normal Population I dwarfs on the upper main sequence (O, B, Am, Ap stars) . Since all globular clusters have turn-off points redder than $(B-V)_0$=0.36, any field halo dwarf redder than this is a straggler suspect.

Olsen (1980) had applied Strömgren photometry to predict spectral classifications of faint stars and finding lists of potentially interesting objects. He has indetified a category of early F type metal-poor dwarfs (so called "week-lined field blue stragglers" (FBSwl)) among stars brighter than $m_v=8^m$. Their δm_1 values indicate abundances in the interval -0.9¡[Fe/H]¡-0.4. A spectroscopic investigation of this group of metal-deficient F dwarfs to clarify their nature was recommended.

FBSwl may be old, metal-poor close binary systems, in wich the former secondaries have gained mass by transfer of material from the former primaries. Alternatively Bond suggested that FBS possibly are cool representatives of the λ Boo class of young stars with weak metallic lines. These λ Boo stars are Pop I hydrogen burning metal poor (except C,N,O and S) A type stars. They fall into two classes with normal (NHL) and peculiar (PHL) hydrogen profiles with weak cores and broad but often shallow wings, have a weak λ4481 lines, often have high $v \sin i$. Relative to a temperature type based on the hydrogen-line cores, the K- and metallic-line types are too early, thus spectrum as a whole appears metal weak. Some of them have IR excesses and strong absorbtion features in IUE spectra. Probably both explanation may be true.

2. Observations and results of spectral analysis

For program stars was obtained high-resolution and high S/N RETICON spectra and two photographic spectra. Preliminary results had been published in Andrievsky et al. (1995, 1996).

RETICON spectra have been obtained with the AURELIE spectrograph on the 1.52m telescope of OHP (Haute Provence Observatory, France). The resolving power was about 11000, signal-to-noise ratio varies from S/N $\approx$ 100. The reduction of the RETICON spectra has been done with an automatic code developed in Paris-Meudon Observatory.

Table 1: Observations and adopted parameters of program stars.

Star	Obs	Region Å	T_{eff},K	*log g*	V_t,km s^{-1}	*v sini*,km s^{-1}
HD11940	OHP	5480-6400	6800	3.6	3.0	60
HD27291	OHP	5480-6800	6750	4.2	2.0	35
HD27523	OHP	5480-6800	6800	3.8	2.2	50
HD35863	OHP	5480-6800	6700	4.0	2.0	23
HD36229	OHP	5480-6400	7100	4.0	2.3	40
HD45042	OHP	5480-6800	6670	3.5	3.0	55
HD54073	OHP	5480-6800	6900	3.2	3.0	120
HD81539	OHP	5480-6800	6500	3.5	1.7	27
HD88923	OHP	5480-6800	6650	3.2	3.0	130
HD119562	OHP	5480-6800	6700	4.0	2.2	40
HD171566	SAO	3900-5000	7100	3.5	4.0	55
HD189652	SAO	3900-5000	6850	3.8	4.0	110

Table 2: Abundances for program stars (SAO spectra)

El	C	Mg	Ca	Sc	Ti	V	Cr	Mn	Fe	Ni	Y	Zr	Ba	Nd
HD171566		-0.3	-0.6	-0.9	-1.0	-0.4	-0.8	-0.4	-1.2	-0.3	-0.3	-0.3	-0.2	-0.3
HD189652	-0.1:	-0.3	-1.3	-1.1	-1.0		-0.7	-0.3	-0.9	-0.7			-0.4	

Table 3: Abundances for program stars (OHP spectra)

El	C	O	Na	Mg	Si	S	Ca	Sc	Ti	Cr	Fe	Ni	Ba
HD11940	-0.2:	-0.2:	-0.2		-0.5	0.0	-0.5	-0.4			-0.5	-0.4	-0.6
HD27291	-0.1:	-0.3:	-0.2	-0.4	-0.2	0.0	-0.4	-0.4	-0.2		-0.2	-0.2	0.0
HD27523	-0.2:	-0.2:	-0.1	-0.4	-0.2	-0.2	-0.3	-0.5		-0.2	-0.3	-0.6	0.0
HD35863	-0.2:	-0.1:	0.0	-0.5	-0.3	-0.1	-0.1	-0.3	-0.3	-0.2	-0.2	-0.4	0.2
HD36229	-0.3:	-0.2:	-0.4	-0.5	-0.3		-0.1	-0.3		-0.3	-0.2	-0.2	-0.1
HD45042	-0.2:		-0.2	-0.8	-0.2	0.0	-0.1	-0.5	-0.2	-0.4	-0.5	-0.6	-0.3
HD54073			-0.3	-1.2	-0.5	0.0	-0.6	-1.1	-0.3	-0.4	-1.0	-0.5	-0.8
HD81539	-0.1:	-0.3:	-0.1	-0.5	-0.5	-0.3	-0.3	-0.8	-0.4	-0.4	-0.3	-0.4	-0.1
HD88923	-0.2:	-0.2:	0.0	-1.0	-0.5	0.0	-0.7	-1.1	-0.3	-0.2	-1.0	-0.4	-0.4
HD119562		-0.2:	0.0	-0.4	-0.2	-0.2	-0.3	-0.6	-0.2	-0.3	-0.3	-0.4	-0.3

Photographic (SAO) spectra have been obtained with 6m telescope Main Stellar Spectrograph (Special Astrophysical Observatory of Russian Academy of Sciences, Russia, Nothern Caucasus (SAO)). The preliminary reduction of the spectrogramss was carried out with an automatical sytem of Crimean Astrophysical Observatory (Academy of Sciences of Ukraine). Dispersion was 9 Å/mm.

Temperatures and gravities of the program stars were estimated using (b-y)-c_1 grid by Kurucz (1991). Strömgren colours were selected from Hauck and Mermilliod (1985). To derive elemental abundances we applied spectral synthesis technique (STARSP code by Tsymbal (1996); atmosphere models come from Kurucz, 1992). Oscillator strengths for investigated lines and blends were corrected performing a procedure of comparison of the solar synthetic spectrum (solar model from Kurucz's grid, V_t=1 km s^{-1} and solar abundances from Grevesse and Noels, 1993) with the solar flux spectrum (Kurucz et al. 1984). Resulting abundances and rotational velocities were found by means of the optimal fitting of the synthetic spectrum to the observed one. Derived abundances for program stars in form [El/H] are given in Tables 2, 3.

3. Discussion

Chemical abundances have changed only for stars with high velocity of rotation, for stars with low velocity of rotation abundances haven't change at all (or a little). *v sin i* values was updated from the preliminary etimates in Andrievsky et al. (1995).

All metals show moderate deficiency on FBS. C and O are in little deficiency on all stars, but lines were very blended and abundance of these elements should be check one more times. But obviously that C and O enhanced with respect to iron. Most of the stars show normal abundance of sulfur (the same for λ Boo type stars). All stars have rather low space velocities and eccentricities (Andrievky et al. 1996). Take into account normal hydrogen profiles of stars we can call them candidates in NHL type stars (of course if all other main features of λ Boo type stars will be found on these stars).

Some of FBSwl and λ Boo type stars have common points on luminosity-temperature diagram that was build by using Hipparcos data and evolutionary isochrones Shaller (1992). As you can see from Tables 2, 3 these stars don't show evident abundance pattern. Possibly FBSwl form an inhomogeneous group wich consist of the stars with different ages (and may be of different types).

The lithium abundance on FBS HD27523, HD45042, HD35863 and HD88923 seem to be equal to its initial abundance expected from the age of the stars. This fact is puzzling, since generally lithium is depleted in BS (Glaspey et al. 1994). Explanation would be that the stars are a young massive stars, formed recently from abnormally metal-poor material. The coalescence of two low-mass stars and BS formation are excluded, lithium will rapidly destroyed in the deep convective zone of cool low-mass dwarfs in the pre-main sequence and main sequence phases, unless the stars are a short-period binaries. Definitive conclusion can be reached if we will have a statistics of such lithium abundance in higher resolution and signal/noice spectra of FBS.

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