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Subdwarfs: CNO abundances

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Abstract. CNO abundances in the atmospheres of seven metal–deficient stars were derived by the model atmosphere method on the basis of high dispersion echelle spectra obtained at the 6 m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences. The O abundances were derived from the lines of the IR–triplet OI 7773 Å. The $C_2(0,1)$ bandhead of the Swan $A^3\Pi_g - X^3\Pi_u$ system at 5635.5 Å was used to determine the C abundances. To estimate the nitrogen abundances, the CN red system $A^2\Pi - X^2\Sigma$ was used, CN (5,1) 6332.18 Å and (6,2) 6478.48 Å bandheads were considered.

The obtained [O/Fe] values confirm the trend of [O/Fe] vs [Fe/H]. For the stars of our sample with $[Fe/H] > -1.00$ we found that nitrogen is overabundant relative to iron, carbon is underabundant.

Key words: stars: abundances – stars: atmospheres – stars: light elements

1. Introduction

Stars with large proper motions represent the old population of the Galaxy. Their atmospheres reflect the chemical composition of the interstellar medium at the time the stars were formed, and the study of element abundances in the atmospheres of unevolved stars confirm the process of star formation to take place at the early stage of evolution of the Galaxy.

In this work we investigate CNO abundances in the atmospheres of metal–deficient stars (with large proper motions) from atomic and molecular spectral features by the synthetic spectrum method.

2. Observations and atmosphere parameters

The program stars were selected from the survey of Laird et al. (1988) and Carney et al. (1994). The observations were carried out at the 6 m telescope echelle spectrometer LYNX (Panchuk et al., 1993) equipped with a CCD of 530×580 pixels. The spectral resolution $R = 25000$, S/N ratio was larger than 100 within the wavelength range 5200 – 8800 Å. Echelle spectra were processed using the program of Galazutdinov (1992). At convolution procedure the full width of spectral line at half maximum was adopted FWHM = 0.25 Å.

Basic data and model atmosphere parameters are given in Table 1 (for details see Klochkova et al., 1996).

Table 1: *The main data of the stars*

Star	V	$T_{\rm eff}$	$\log g$	[Fe/H]	V_t
HD 64090	8.28	5370	3.0	-1.76	2.5
G29-20	9.17	5030	2.0	-0.91	1.2
G122-57	8.36	5040	3.0	-0.33	1.0
G182-7	8.10	5500	4.2	-0.14	2.0
G188-22	10.05	5860	3.5	-1.43	1.7
G246-38	9.91	5240	3.5	-2.00	3.5
G265-1	8.37	5500	3.0	-0.65	1.5

3. Synthetic spectra for CNO abundance determination

CNO abundances were derived with the synthetic spectrum method by the program STARSP (Tsymbal, 1994). The model atmospheres for each star were obtained by interpolations in the grids of model atmospheres by Bell et al. (1976) and Kurucz (1979). The choice of atmosphere parameters was controlled by the Fe I lines in the region of the spectral features used for this analysis. The accuracy of the abundance determination was 0.3 dex. The list of atomic and molecular lines and oscillator strengths $\log gf$ for atomic lines were taken from (Kurucz, 1993). Figs. 1 and 2 show a comparison of the calculated spectrum with the observed one in the region of the IR–triplet OI 7773 Å and of the Swan system band 5635.5 Å for the subdwarf G122–57.

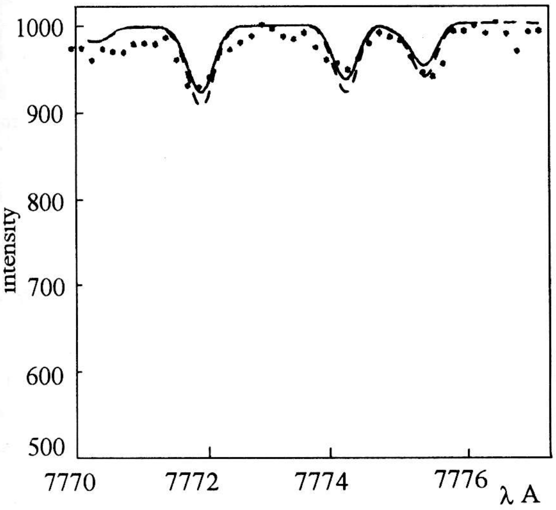

Figure 1: *Comparison between the observed (points) and synthetic (solid line – lg A(O)=8.70; dashed line lg A(O)=8.90) spectra of the subdwarf G122-57 in the region of the IR–triplet* OI 7773 Å.

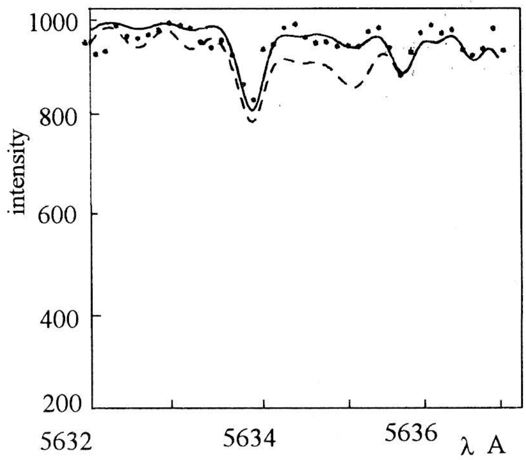

Figure 2: *Comparison between the observed (asterisks) and synthetic (solid line – lg A(C)=8.20; dashed line – lg A(C)=8.40) spectra of the subdwarf G122-57 in the region of the* C_2 *features.*

Oxygen. The O abundances were derived from lines of the IR–triplet OI 7773 Å. These lines were visible in the spectra of all studied stars, the [OI] 6300 Å line was too weak and contaminated by telluric lines. As it was found by King and Boesgaard (1995), for $T_{\rm eff} < 6200$ K there is no systematic difference between the [OI] 6300 Å and 7774 Å abundances for metal–poor giants or dwarfs.

Carbon. The $C_2(0,1)$ bandhead of the Swan $A^3\Pi_g - X^3\Pi_u$ system at 5635.5 Å was used to determine the C abundances. In the molecular line list close to $C_2(0,1)$ features there are the blending lines of the CN molecule. As follows from our calculations their influence becomes essential at temperatures lower than 5000 K.

Values of $\log gf$ for C_2 lines were corrected according to Shavrina and Kuznetsova (1996), a dissociation potential of the carbon molecule C_2 equal to $D(C_2) = 6.15$ eV was used.

Nitrogen. To estimate the nitrogen abundances, the CN red system $A^2\Pi - X^2\Sigma$ was used, the CN (5,1) 6332.18 Å and (6,2) 6478.48 Å were considered. The value of dissociation potential was adopted $D(C_2) = 7.76$ eV. As for atomic carbon and nitrogen lines, the available molecular bands were too weak (not measurable) in metal–deficient stars in which $[Fe/H] < -1.0$ and $T_{\rm eff} > 5000$ K. As shown in our calculations, the bands are measurable at $[Fe/H] < -1.0$, at temperatures lower than 4500 K. The C and N abundances were obtained for stars with $[Fe/H] > -1.0$. The results are given in Tables 2 and 3.

Table 2: *CNO abundances for the program stars (at* $\log N(H) = 12$*)*

Star	[Fe/H]	log ϵ(C)	log ϵ(N)	log ϵ(O)
HD 64090	-1.76	-	-	8.40
G29-20	-0.91	7.80	7.30	8.35
G122-57	-0.33	8.20	7.90	8.70
G182-7	-0.14	8.40	8.00	8.40
G188-22	-1.43	-	-	8.00
G246-38	-2.00	-	-	7.70
G265-1	-0.65	8.04	7.6:	8.65

Table 3: *Relative CNO abundances*

Star	[C/Fe]	[N/Fe]	[O/Fe]
HD 64090	-	-	+0.39
G29-20	-0.10	+0.30	+0.35
G122-57	-0.20	+0.30	+0.15
G182-7	-0.16	+0.10	-0.36
G188-22	-	-	+0.50
G246-38	-	-	+0.80
G265-1	0.00	+0.26:	+0.29

4. Discussion of results

Oxygen. According to the recently stellar evolution theory, oxygen is transformed into nitrogen in deep layers of a star and is not dredged up to its surface. Therefore, the O abundance in the case of unevolved and evolved stars characterizes the chemical composition of matter from which stars were formed.

For investigated metal–deficient stars it has been obtained that O is overabundant relative to iron. Our values [O/Fe] confirm also the trend of [O/Fe]vs[Fe/H] shown by many authors (for example, Sneden et al., 1979; Barbuy, 1983 etc.) who suggested that the halo was overabundant in oxygen with respect to iron at the early times. Matteucci and François (1992) discuss the behaviour of [O/Fe]vs[Fe/H] and the change in the slope of the [O/Fe] ratio occurring at [Fe/H] $= -1.7$, as claimed recently by Bessel et al. (1991). They show that the change can be reproduced by a model where the star formation rate is almost linear with gas density and the iron production from massive stars is lower than previously assumed. A squared dependence of the star formation rate on the gas density will produce an almost constant [O/Fe] ratio between -3.0 and -1.0 in [Fe/H].

Carbon and nitrogen. The standard theory of stellar nucleosynthesis predicts that matter enriched with CN–cycle products is transferred to the surface layers of stars, therefore in the atmospheres of the evolved stars C and N may be expected to be underabundant and overabundant, respectively. According to these predictions, we have found for the stars with [Fe/H] > -1.0 that nitrogen is overabundant relative to iron, carbon is underabundant.

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References

Barbuy B., 1983, Astron. Astrophys., **123**, 1

Bell, R.A., Eriksson K., Gustafsson B., Nordlund A., 1976, Astrophys. J. Suppl. Ser., **23**, 37

Bessel M.S., Sutherland R.S., Ruan K., 1991, Astrophys. J., **383**, L7.

Carney B.W., Latham D.W., Laird J.B., Aguilar L.A., 1994, Astron. J., **107**, 2240

Galazutdinov G.A., 1992, Preprint Spec. Astrophys. Obs., **92**

King J.R., Boesgaard A.M., 1995, Astron. J., **109**, 383

Klochkova V.G., Mal'kova G.A., Panchuk V.E., 1996, Bull. Spec. Astrophys. Obs., **39**, 5

Kurucz R.L., 1979, Astrophys. J. Suppl. Ser., **40**, 1

Kurucz R.L., 1993, in: Molecules in the stellar environment, IAU Coll., Copenhagen, Springer–Verlag, No. **100**, 282

Laird J.B., Carney B.W., Latham D.W., 1988, Astron. J., **95**, 1843

Matteucci F., François P., 1992, Astron. Astrophys., **262**, L1

Panchuk V.E., Klochkova V.G., Galazutdinov G.A., Ryadchenko V.P., Chentsov E.L., 1993, Pis'ma Astron. Zh., **19**, 1061

Sneden C., Lampert D.L., Whitaker R.N., 1979, Astrophys. J., **234**, 964

Shavrina A.V., Kuznetsova L.A., 1996, (private communication)

Tsymbal V. V., 1994, Odessa Astron. Publ. **7**, 146