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CNO and Li abundances in Barium-enriched stars

Natalia A. Drake[1,2] and Claudio B. Pereira[1]

[1]Observatório Nacional/MCT, Rua José Cristino, 77, Rio de Janeiro 20921-400, Brazil
email: drake@on.br, claudio@on.br

[2]Sobolev Astronomical Institute, St. Petersburg State University, Universitetski pr. 28, St. Petersburg 198504, Russia.

Abstract. CNO and Li abundances and $^{12}C/^{13}C$ isotopic ratios have been derived for two metal-poor Ba giants, HD 104340 and HD 206983, and two CH subgiants, HD 50264 and HD 87080. High resolution spectra obtained with the 1.52 m telescope and the FEROS echelle spectrograph at ESO, La Silla, Chile, were used in this study. CNO and Li abundances so as $^{12}C/^{13}C$ isotopic ratios were determined by applying the synthetic spectrum method to the lines of C_2, CH, CN, [O I] and Li I. Our analysis showed that the giant stars studied here have quite different natures: HD 206983 is a metal-poor barium star while HD 104340, although showing enhancement of *s*-process elements, should not be considered as a classical barium star: its barium syndrome can be explained by internal nucleosynthesis. The low metallicity giant HD 104340 can experience deeper convective mixing and, consequently, a larger dredge-up of CNO-cycle products compared to normal red giants. Light element abundance pattern of HD 104340 resembles anomalies resulting from the appearance on the stellar surface of material enriched in triple-α and CNO cycling.

Keywords. Stars: chemically peculiar, stars: abundances, stars: evolution, stars: individual (HD 50264, HD 87080, HD 104340, HD 206983)

1. Introduction

Barium-enriched stars represent a class of chemically peculiar stars that show enhancement of carbon and heavy elements produced by *s*-process nucleosynthesis. The discovery of binarity in barium stars became a key to understanding their nature (McClure *et al.* 1980). Mass transfer from a companion – He-burning AGB star, which is now an optically invisible white dwarf, was proposed to explain observed chemical peculiarities in barium stars.

CNO and Li abundances and $^{12}C/^{13}C$ isotope ratio determinations play an important role in our understanding of the evolution, convection, and nucleosynthesis history of barium-enriched stars. However, the light element abundances have not yet been extensively studied in these stars. CNO and Li abundances as well as $^{12}C/^{13}C$ isotope ratios are available only for a limited sample of Ba stars (see, for example, Sneden *et al.* 1981; Sneden 1983; Barbuy *et al.* 1992; Vanture 1992a, 1992b; Lambert *et al.* 1993, Smith *et al.* 1993; Allen & Barbuy 2006; Gopka *et al.* 2006; Drake & Pereira 2006 and references herein)

In this work we present the results of light element determination for two metal-poor barium giants, HD 104340 and HD 206983, and two CH subgiants, HD 50264 and HD 87080. The abundances of *s*-process elements in the atmospheres of these stars have been studied in Junqueira & Pereira (2001) and Pereira & Junqueira (2003).

2. Analysis and discussion

The high resolution spectra ($R = 48\,000$) of the stars analyzed in this work were obtained at the 1.52m ESO telescope of La Silla, Chile, with the FEROS (Fiberfed Extended Range Optical Spectrograph) echelle spectrograph.

The stellar parameters adopted in this work were those taken from Junquiera & Pereira (2001) and Pereira & Junquiera (2003).

CNO and Li abundances and $^{12}C/^{13}C$ isotope ratios were determined using the synthetic spectrum method. The last version (April 2002) of the spectral synthesis code MOOG (Sneden 1973) was used. The lines of molecules C_2, CH, and CN, forbidden oxygen line at 6300.304 Å, infrared oxygen triplet at ∼7770 Å, and the Li I resonance doublet at 6708 Å were used for abundance determinations. The lines of the *s*-process elements were added from the D.R.E.A.M. database (Database on Rare-Earths At Mons University). The detailed description of the line lists used in this study can be found in Drake & Pereira (2006). An example of the abundance determination is given in Fig. 1. This figure shows the observed and synthetic spectra of HD 104340 and HD 206983 in the spectral region containing ^{12}CN and ^{13}CN molecular lines.

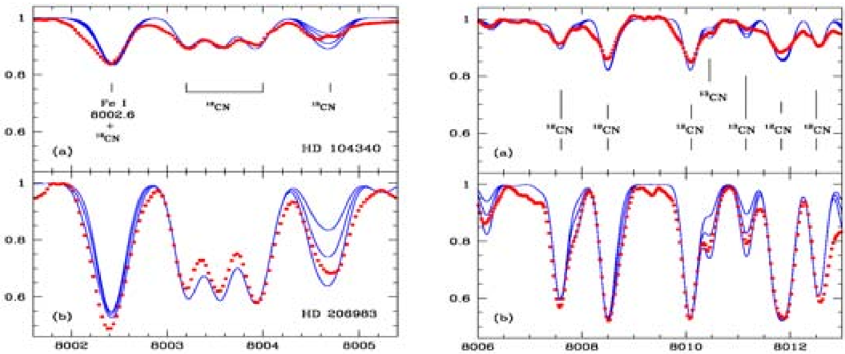

Figure 1. Observed (dotted line) and synthetic spectra (solid lines) between 8000 Å and 8013 Å for the stars HD 104340 (a) and HD 206983 (b). For HD 104340 synthetic spectra were calculated with carbon isotope ratio $^{12}C/^{13}C = 8$, 6, 4.5, and 3.6 while for HD 206983 $^{12}C/^{13}C = 32$, 16, and 8.

Determined values of CNO and Li abundances and $^{12}C/^{13}C$ isotope ratios are shown in Table 1 together with the stellar atmosphere parameters, such as $T_{\rm eff}$, $\log g$, and [Fe/H]. The usual spectroscopic definition $[X/H] = \log\epsilon(X)_* - \log\epsilon(X)_\odot$ and $\log\epsilon(X) = \log N_X/N_H + 12.0$ was used.

Comparison of the relative CNO abundances (log O/N *versus* log C/N and $^{12}C/^{16}O$ *versus* $^{12}C/^{13}C$) for stars analyzed in this work and other samples of stars with known CNO abundances clearly showed that two Ba-enriched giants studied here have quite different nature. HD 104340 although showing enhancement of *s*-process elements and previously classified as a metal deficient barium star by Luck & Bond (1991) should not be considered as a barium star that has undergone mass transfer. The light elements abundance pattern of HD 104340 resembles anomalies resulting from the appearance on the stellar surface of material enriched in triple-α and CNO cycling. High [N/Fe] ratio of +0.84 indicates that this star experiences deep convective mixing. The high values of [N/Fe] have already been reported in metal-poor giants (Carreta *et al.* 2000; Spite *et al.* 2005) which is taken as an evidence of more effective mixing. CORAVEL radial-velocity measurements of HD 104340 spanning several years did not show any indication

Table 1. CNO and Li abundances and $^{12}C/^{13}C$ isotope ratios for studied stars

Star ($T_{\rm eff}$/ log g)	log ϵ(Li)	log ϵ(C)	log ϵ(N)	log ϵ(O)	$^{12}C/^{13}C$	[Fe/H]	[C/Fe]	[N/Fe]	[O/Fe]
HD 50264 (5800/4.2)	$\leqslant 0.1$	8.47	7.95	8.61	50	−0.34	+0.25	+0.24	+0.02
HD 87080 (5600/4.0)	$\leqslant 0.8$	8.38	7.76	8.62	30	−0.51	+0.33	+0.22	+0.19
HD 104340 (4350/1.2)	$\leqslant -0.7$	7.21	7.17	8.03	4.5	−1.72	+0.37	+0.84	+0.50
HD 206983 (4200/1.4)	−1.2	7.97	7.74	8.15	9	−1.43	+0.84	+1.41	+0.65

of orbital motion (Jorissen et al. 2005). Our spectrum of HD 104340 shows asymmetric profiles of absorption lines typical for pulsating stars. Spectral monitoring is needed to clarify eventual pulsation motions of the photosphere of this star.

The carbon and *s*-process element abundances of HD 206983, as well as the $^{12}C/^{13}C$ ratio, are similar to those seen in barium and CH stars, thus reinforcing the idea that this star should be a metal-poor barium star. Radial velocity measurements are necessary to confirm its binary nature.

Two subgiants, HD 50264 and HD 87080, show low lithium abundance and enhancement of carbon and nitrogen. No significant enhancement of ^{13}C is observed. The origin of the abundance peculiarities in these stars is a mass transfer of carbon- and *s*-process rich material from an evolved companion that was a thermally pulsing AGB star.

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References

Allen, D.M. & Barbuy, B. 2006, *A&A* 454, 895
Barbuy, B., Jorissen, A., Rossi, S.C.F., & Arnould, M. 1992, *A&A* 262, 216
Carretta, E., Gratton, R.G., & Sneden, C. 2000, *A&A* 356, 238
Drake, N.A. & Pereira, C.B. 2006, *A&A* (submitted)
Gopka, V., Yushchenko, A., Lambert, D., Drake, N., & Rosptopchin, S. 2006, in: *Nuclei in the Cosmos-IX*, Proc. of International Symp. on Nuclear Astrophysics, CERN, Switzerland (in press)
Jorissen, A., Zacs, L., Udry, S., Lindgren, H., & Musaev, F.A. 2005, *A&A* 441, 1135
Junqueira, S. & Pereira, C.B. 2001, *AJ* 122, 360
Lambert, D.L., Smith, V.V. & Heath, J. 1993, *PASP* 105, 568
Luck, R.E. & Bond, H.T. 1993, *ApJS* 77, 515
McClure, R.D., Fletcher, L.M., & Nemec, J.M. 1980, *ApJ* (Letters) 338, L35
Pereira, C.B. & Junqueira, S. 2003, *A&A* 402, 1061
Smith, V.V., Coleman, H., & Lambert, D.L. 1993, *ApJ* 417, 287
Sneden, C. 1973, *ApJ* 184, 839
Sneden, C., Pilachowski, C.A., & Lambert, D.L. 1981, *PASP* 95, 745
Sneden, C. 1983, *ApJ* 184, 839
Spite, M., Cayrel, R., Plez, B., Hill, V., & Spite, F., *et al.* 2005, *A&A* 430, 655
Vanture, A. 1992a, *AJ* 104, 1986
Vanture, A. 1992b, *AJ* 104, 1997