Atmospheric parameters and abundances of λ Bootis stars

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Abstract. The results of the abundance analyses of six λ Bootis stars are presented. For three stars, the impact of individual ODFs and various treatments of convection in the calculactions of the model atmospheres are investigated.

Key words: Convection – Stars: abundances – Stars: atmospheres – Stars: chemically peculiar – Stars: early type

1. Introduction

As has been discussed in the course of this workshop, the classification of λ Bootis stars is not as simple and straightforward as for other groups of chemically peculiar stars. When only low resolution classification spectra are used, it is likely that stars with different astrophysical properties but similar characteristics in the narrow spectral range are included. Therefore a detailed spectroscopic investigation for a large number of confirmed λ Bootis stars (e.g. Paunzen et al. 1997) covering the whole range of atmospheric parameters is required to establish a common abundance pattern for these stars. Up to now we have analyzed the chemical composition of six λ Bootis stars where two of them turned out to be spectroscopic binaries (Paunzen et al. 1998).

In order to put our results on more solid ground we investigated the impact of using different programmes for the calculation of the model atmospheres on the abundances of three stars with different temperatures, gravities and metallicities (Heiter et al. 1998). The two issues we examined concerned the inclusion of individual line opacities and the calculation of the convective flux in the model atmospheres.

2. Observations and analysis

High resolution spectra with high signal-to-noise ratios have been obtained at various sites as listed in Table 1. They have been reduced with NOAO IRAF (Willmarth & Barnes 1994), and atmospheric parameters and abundances have been derived as described by Gelbmann et al. (1997, 1998). The resulting atmospheric parameters are presented in Table 2. The abundances of each element

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Table 1. Observations used for this analysis.

HD	Observatory	[m]	Spectrograph	Date	Observer
84123 **84948**	Asiago (Italy)	1.8	Echelle	3–1995, 2–1997	Heiter
142703	OPD/LNA (Brazil)	1.6	Coudé	6–1995	Paunzen
171948	McDonald (Texas)	2.1	Sandiford Echelle	4–1996	Handler
183324 **192640**	OHP (France)	1.5	Aurelie	6/8–1994	Gelbmann +Kuschnig

HD	Wavelength range [Å]	Resolution	S/N
84123 **84948**	4000−7200	30000	150
142703	4100−4900	30000	100
171948	4290−4730	60000	150
183324 **192640**	3800−5300, 5800−6000 +5900−6280, 7050−7230	20000	200

Table 2. Atmospheric parameters of the programme stars.

star HD	T_{eff} (±200 K)	log g (±0.3)	v_{turb} ($\pm 0.5\,\mathrm{km\,s^{-1}}$)	[Z]	v sin i [$\mathrm{km\,s^{-1}}$]
84123	6800	3.5	3.0	−1.0	15(5)
84948A	6600	3.3	3.5	−1.0	45(5)
84948B	6800	3.7	3.5	−1.0	55(5)
142703	7000	3.7	3.0	−1.5	100(10)
171948A	9000	4.0	2.0	−2.0	15(5)
171948B	9000	4.0	2.0	−2.0	10(5)
183324	9300	4.3	3.0	−1.5	90(10)
192640	7800	4.0	3.0	−2.0	80(10)

for which at least one "unblended" line could be detected in the observed spectra of the programme stars are plotted in Figs. 1 and 2. "Unblended" means that no other line with a depth greater than 30 % of that of the examined line is found within a wavelength window whose width depends mainly on the $v \sin i$ of the respective star.

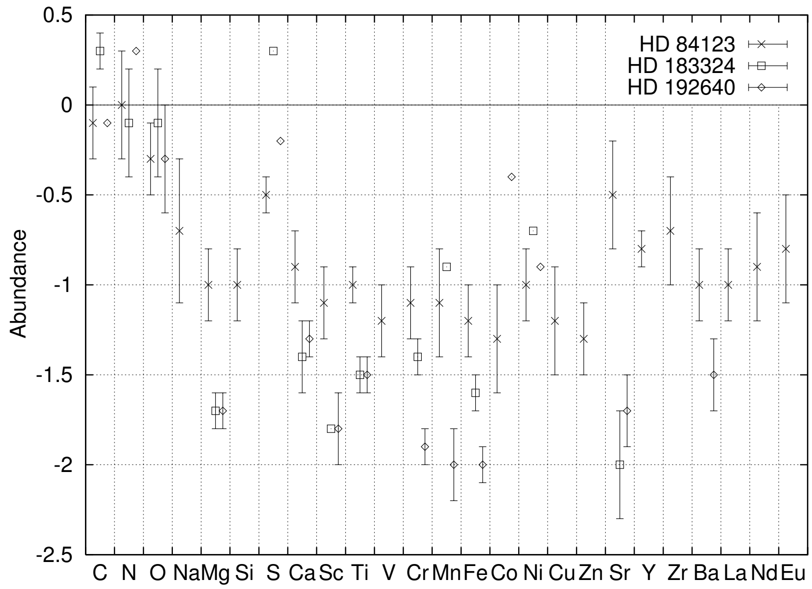

Figure 1. Logarithmic abundances relative to the sun for three programme stars. Points without error bars indicate upper limits for the abundances.

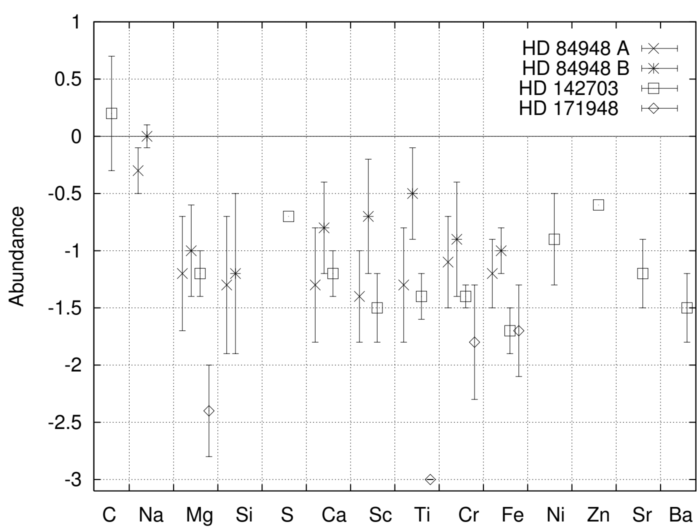

Figure 2. Same as Fig. 1 for the remaining programme stars.

3. Self-consistent model atmospheres

The abundances of the three stars from Fig. 1 were used to calculate individual opacity distribution functions (ODFs) for these stars with a programme written by N. Piskunov (Piskunov & Kupka 1998). The subsequent inclusion of these ODFs in the model atmosphere calculations instead of the tabulated opacities from Kurucz (1993) showed that the $T(\tau)$-relations and therefore the synthetic spectra of all three stars do not change significantly.

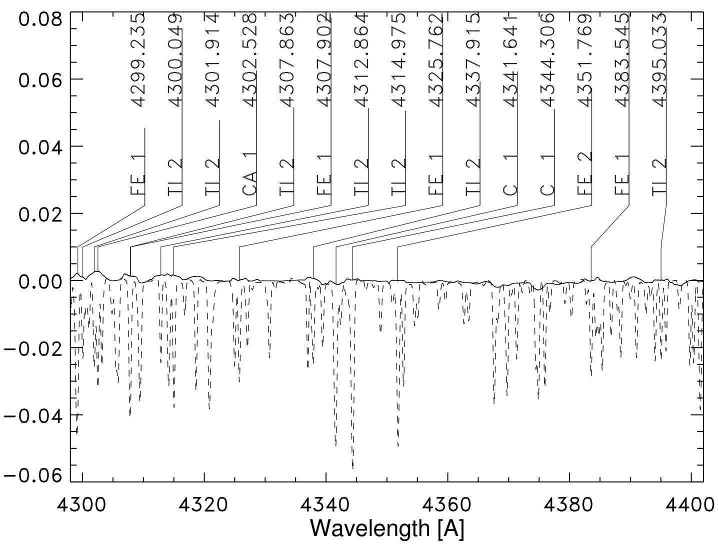

Figure 3. Difference between normalized synthetic spectra calculated with CM and MLT. The solid and dashed lines represent HD 192640 and HD 84123, respectively.

In the next step we compared the results of the original ATLAS9 programme (Kurucz 1993, MLT) with three versions where the treatment of convection (or overshooting) had been changed: 1) Deletion of the part of the programme concerning the overshooting (NO), 2) Implementation of the convection model by Canuto & Mazzitelli (1991, CM), 3) Variation of the treatment of overshooting (Castelli 1996, OVOK). The differences can be summarized as follows: Using the NO version results in similar changes compared to MLT as for the CM model, whereas OVOK yields practically the same $T(\tau)$-relation as MLT. For HD 84123, the largest differences occur in the visible spectral range (see Fig. 3), where the abundances of all elements would have to be decreased by 0.1 dex to match the MLT calculations. For HD 192640, significant differences are only seen in the UV spectral range (Fig. 4). The CM flux seems to represent the observations better than that of MLT. Note the absorption feature at 1600 Å, which cannot be reproduced by either of the models. For the hottest of the stars, HD 183324, the differences are negligible.

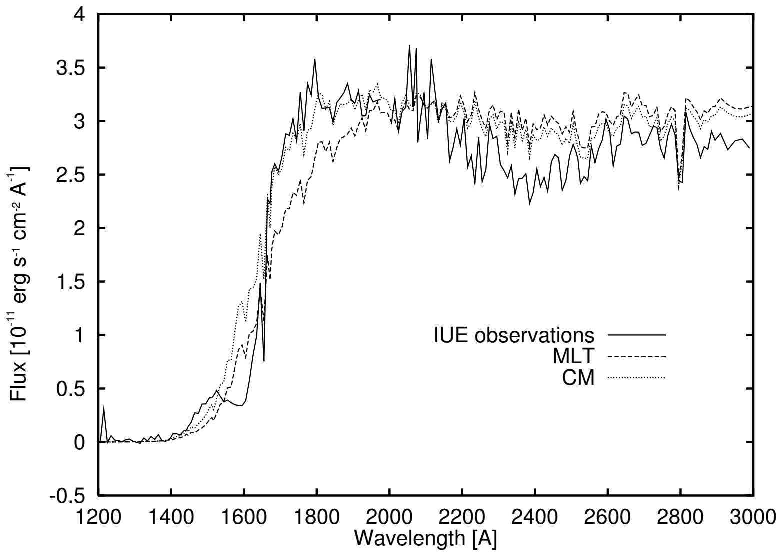

Figure 4. Comparison of synthetic surface fluxes with IUE observations for HD 192640.

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