Accurate LTE abundances for some λ Boo stars

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Abstract. High-resolution and high S/N CCD spectra were analyzed to determine accurate LTE abundances in four λ Boo stars: π^1 Ori, 29 Cyg, HR 8203 and 15 And. In general, 14 chemical elements were investigated. The main results are the following: all stars have a strong deficiency of the majority of investigated metals. Oxygen exhibits a moderate deficiency. The carbon abundance is close to the solar one.

The results obtained support an accretion/diffusion model, which is currently adopted for the explanation of the λ Boo phenomenon.

Key words: Stars: λ Boo – Stars: chemically peculiar

1. Introduction

Among the unresolved problems of stellar astrophysics, there is one linked with the λ Boo phenomenon. A comprehensive review of the λ Boo phenomenon was recently provided by Stürenburg (1993) and by Paunzen et al. (1997).

To explain the λ Boo phenomenon, Venn and Lambert (1990) adopted an accretion hypothesis. According to that hypothesis, the chemical peculiarity of λ Boo stars originates due to the presence of a circumstellar shell. The circumstellar shell consists of two phases: gas and dust grains. The dust grains accumulate metals having a high condensation temperature (e.g. Si, Fe), but elements with lower condensation temperature (C, N) remain in the gaseous phase. Depleted gas from the circumstellar envelope is accreted by the star, while dust grains drift out of the shell due to radiative pressure.

Further studies of the proposed accretion scenario were made by Charbonneau (1991, 1993), who combined it with the theory of diffusion. Attempts to derive accurate elemental abundances in the atmospheres of λ Boo stars were undertaken in several works (Venn and Lambert, 1990; Stürenburg, 1993, etc).

2. Observation

The CCD spectra have been obtained with the échelle spectrometer LYNX on the 6m telescope (Special Astrophysical Observatory of the Russian Academy

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Table 1. Characteristics of programme stars.

Star	(b-y)	c_1	$v \sin i$, $\mathrm{km\,s^{-1}}$	$T_{\rm eff}$,K	$\log g$
HR1570	0.044	1.007	105	8750	4.2
HR7736	0.101	0.927	80	8000	4.2
HR8203	0.093	0.940	65	8300	4.2
HR8947	0.056	1.072	100	9000	4.1

of Sciences, Russia, Northern Caucasus). The detailed description of the spectrometer is given by Panchuk et al. (1993). The resolving power was 24000, S/N $\approx$ 100.

3. Atmospheric parameters

Temperatures and gravities of the programme stars were estimated using the (b-y)-c_1 grid by Kurucz (1991). Strömgren colours were selected from Hauck & Mermilliod (1985), $v \sin i$ values are from the catalogue of Paunzen et al. (1997). For all stars a microturbulent velocity of 3 $\mathrm{km\,s^{-1}}$ was adopted. The results are given in Table 2.

4. Method

To derive elemental abundances, we applied the spectral-synthesis technique (STARSP code by Tsymbal, 1996; atmosphere models come from Kurucz, 1992). Oscillator strengths for the investigated lines and blends were corrected by compariing the solar synthetic spectrum (solar model from Kurucz's grid, V_t=1 $\mathrm{km\,s^{-1}}$ and solar abundances from Grevesse & Noels, 1993) with the solar flux spectrum (Kurucz et al. 1984).

5. Results

In Table 2 we give the individual abundances of the programme stars in the form [El/H]. In the present study we confidently confirmed that carbon has an approximately normal abundance in all investigated stars. Oxygen is moderately deficient. There is also no doubt that most of the heavier elements are strongly deficient in the atmospheres of λ Boo stars.

As it was realized by Venn and Lambert (1990), relative abundances must depend upon the condensation temperature. Our result strongly supports the supposition that the gas from the circumstellar shell, enriched in the elements with low $T_{\rm cond}$ values (C, O, S), is preferentially accreted by the star, while elements with a high condensation temperature (Ca, Ti, Fe, etc) and locked in dust grains, do not reach the stellar atmosphere.

Table 2. Abundances of the programme stars.

El.	π^1 Ori	29 Cyg	HR8203	15 And
C	-0.2	-0.1	-0.2	0.0
O	-0.5	-0.5	-0.5	-0.3
Na	-0.5	-0.4	-0.5	
Mg	-0.8	-1.5	-1.0	-0.5
Si	-1.3	-1.0	-0.8	-1.0
S	-0.4		+0.4	
Ca	-1.0	-0.8	-0.8	-0.6
Sc	-0.8	-0.5	-0.9	-0.6
Ti	-0.7	-1.0	-0.8	-0.6
Cr	-0.6	-1.2	-0.5	-0.4
Fe	-1.0	-1.3	-0.7	-0.8
Ni	-0.5	-0.6	-0.4	
Ba	-0.5	-0.4	0.0	

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