PASCHEN LINES SURVEY OF LAMBDA BOOTIS TYPE STARS

Ilian Kh. Iliev[1]*, Ivanka K. Stateva*[1]*, Ernst Paunzen*[2]*, Ina S. Barzova*[1]

1) Institute of Astronomy, National Astronomical Observatory, P. O. Box 136, BG-4700 Smolyan, Bulgaria
2) Astronomisches Institut der Universität Wien, Türkenschanzstrasse 17, A-1180 Wien, Austria

The small group of stars named after the prototype Lambda Bootis comprises of Population I late-B to early-F type stars with metal deficient atmospheres. The deficit of Fe-peak elements is moderate to strong and reaches up to 2 dex. The abundance of light elements like C, N, O, and S is normal (solar). As a group Lambda Bootis type stars occupy almost the same place in the Herzsprung-Russell diagram as “classical” Am-stars and cool Ap-stars which in opposite exhibit metal-enriched spectra. The attempts to illustrate the question why are Lambda Bootis type stars so interesting are presented in the Table 1. Some of the general characteristics of four different types of stars are reviewed there. Even a simple analysis of the Table 1 shows how important can be the rotation and magnetic fields. The reality is much more complex because other general characteristics of these types of stars such as effective temperature, masses and kinematics are the same. So, what makes the puzzle so variegated?

The region bounded by effective temperature between 10000 K and 7000 K and by absolute magnitude between –1 and +2 is without any doubt the most crowded place in the Herzsprung-Russell diagram. Even the short list contains four types stars from the Table 1 plus field blue strugglers, BHB and HAEBE stars, F-weak, intermediate Population II stars, pre-MS stars, and, of course, Delta Scuti pulsators. Founding the physical reason for each of these groups is a challenging task. Our recent results show that Lambda Bootis type phenomenon occurs under limited physical conditions that puts strong constrains to many important astrophysical processes as radiatively driven diffusion, slow accretion, mass-loss and non-radial pulsations [1, 2].

	Rotation	Metals	Mag. Field	Variability
Normal A-stars	normal	normal	no	no, Delta Scuti
Cool Ap-stars	slow	excess	yes	sp, ph, puls
Am-stars	slow	excess	no	no
LamBoo stars	normal	deficient	no	puls

Fig.1

Some of the leading concepts [3, 4] suggest the crucial role of the interaction with the interstellar (or circumstellar) matter. Both gas and dust around the stars either from proto-stellar debris or from the clouds are considered as a main reason for the observed abundance anomalies. In connection with this we promoted a project targeted to some sensitive spectral lines such as NaD doublet, H-alpha and higher Paschen lines as tracers of ongoing slow accretion of circumstellar matter on the stellar atmospheres. Only the results of our Paschen lines survey are presented here.

Seven bright and pronounced Lambda Bootis type stars were observed in two overlapping spectral frames in the region between the lines Pa13 and Pa22 (centered at ca. 8500 angstroms). Observations were carried out with the coude-spectrograph of the NAO “Rozhen”. Photometrics CCD (1024 x 1024, 24 microns) attached to the Third camera was used to provide the data with signal-to-noise ratio of about 300 and spectral resolution R ~ 25000.

Well-known Inglis-Teller formula connects the electron density Ne with the last resolved hydrogen line number: log Ne = 22.7 – 7.5 log nmax. Thus obtained value of Ne is typical for the uppermost atmospheric layers where the optical depth is close to 0.1. To determine Ne means to find where the appropriate central depth (or equivalent width) of a given hydrogen line approaches zero. Corrections should be made to bare numbers of nmax in order to take into account most of all the overlapping of the line wings due to rotation. In faster rotating cases the lines will “disappear” at smaller nmax values. As a rule, the internal error in nmax determination is about 0.2.

A0-F0	ZAMS	mid-MS	TAMS	sub-giant
nmax	17	18.5	20	21

Fig. 2

Just for comparison in the Table 2 we present the typical values of nmax for A0-F0 stars on different stages of their main sequence evolution. Our results together with some basic information about the stars studied are presented in Table 3. Last two columns (marked with IB) contain data taken from our paper [5]. Rozhen photographic plates and Balmer lines have been used there. Even if we take into account the big differences in the signal-to-noise level only, a conclusion can be drawn that the discrepancy between new CCD and old photographic data is not very large. As it can be seen most of the stars have Ne (and nmax) values typical for the normal A-stars. Only for the HD192640 and for the HD221756 larger nmax numbers can be interpreted as signs of an extended “giant-like” atmosphere. Does it mean that the accretion around other stars in our list is already ceased? To answer this question future observations are badly needed.

HD	Teff	log g	vsini	n_{max}	logN$_e$	n_{max} (IB)	logN$_e$ (IB)
31295	8920	4.20	123	20.0	13.24	18.7	13.16
91130	8135	3.78	152	19.9	13.25	--	--
110411	8970	4.36	154	19.8	13.28	18.2	13.25
125162	8720	4.07	115	17.8	13.63	--	--
183324	8950	4.13	100	17.5	13.67	18.3	13.23
192640	7940	3.95	80	21.1	13.08	19.9	12.96
221756	8510	3.90	105	20.5	13.17	19.7	12.99

Fig. 3

The last paragraph is addressed to a topic far beyond the scope of this contribution. Here we want to share our experience to observe spectroscopically in the near-infrared. Nearly a dozen years after the end of the Photographic Era high-resolution stellar spectroscopy continues like “rhapsody in blue”. The winning policy, in our opinion, is to behave as the light detector does. CCD observations are much more efficient in red and infrared regions simply because the chip is much more sensitive at those wavelengths. Even the lower resolution (because of having lower order spectra) is good prise for it. We agree that looking for new spectral regions and new sets of convenient lines with well-studied atomic constants in red and infrared for many chemical elements is not an easy task, but the result always is worth the efforts.

Acknowledgements. This study is supported in part by the National Science Fund under grant F-1403/2004.

REFERENCES

1. Iliev, I. Kh., Paunzen, E. Barzova, I., Kamp, I., Griffin, R., Claret, A., Koen, C. First orbital elements for the Lambda Bootis spectroscopic binary systems HD84948 and HD171948, Astron. & Astrophys., 381, 2002, 914-922
2. Paunzen, E., Iliev, I. Kh., Kamp, I., Barzova, I. The status of Galactic field Lambda Bootis stars in the post-HIPPARCOS era, Monthly Notices of RAS, 336, 2002, 1030-1042
3. Venn, K.A., Lambert, D.A. Chemical composition of three Lambda Bootis stars, Astrophys. J., 363, 1990, 234-244
4. Kamp, I., Paunzen E. The Lambda Bootis phenomenon: Interaction between a star and a diffuse interstellar cloud, Monthly Notices of RAS, 335, 2002, L45-L49
5. Iliev, I. Kh., Barzova, I. Shell signs in the hydrogen-line spectrum of some Lambda Bootis-type stars, CAOSP, 27, 1998, 441-445 (IB)