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A consolidated catalogue of λ Bootis stars[⋆⋆⋆]

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Abstract. λ Bootis stars challenge our understanding of diffusion and accretion processes related to stars and their circumstellar environment, and they are interesting components of the classical instability strip. Attempts to derive group properties with statistical methods are severely limited by the small number of unambiguously identified λ Bootis stars. In general, the subject appears to be obscured by incorrect memberships and it is therefore essential to provide a sufficiently large catalogue of definitive group members before modeling the λ Bootis phenomenon.

This paper describes the first steps towards this goal, based on our current knowledge of well investigated members, leading to a concise definition of λ Bootis stars: *Pop I hydrogen burning metal poor (except of C,N,O and S) A-type stars.* The definition does not depend on phenomenological features, like flux depressions, colour excesses, $v \sin i$ values, etc.

Based on a new homogeneous catalogue with 45 λ Bootis stars, we discuss classification criteria which can be used for a spectroscopic and photometric all-sky survey for λ Bootis stars in the field and in clusters of different ages.

Key words: astronomical data bases — catalogues; stars — λ Bootis ; stars — chemically peculiar; stars — early type

1. Introduction

The λ Bootis stars are a class of metal-poor Population I A-type stars. Although the prototype was already described by Morgan et al. (1943), the definition as a separate class among chemically peculiar (CP) stars is still controversial. λ Bootis stars occupy the same parameter space in a Hertzsprung-Russell-diagram as do "normal" A-type stars, CP1 and cool CP2 stars. Figures 1, 4 and 5 illustrate this coincidence for Geneva and Strömgren colour indices. The plotted colour indices were taken from Hauck & Mermilliod (1990), Handler (1995) for the Strömgren photometric system and from the Geneva database for the Geneva photometric system. The values for the λ Bootis stars are listed in Tables 2 and 3.

The evolutionary status of λ Bootis stars is not clear yet. The two theories discussed in the literature exclude each other and observations are not yet conclusive enough for a decision. These theories involve either accretion of interstellar matter, or a combination of diffusion and mass loss. λ Bootis stars would therefore provide excellent tests for processes which play a considerable rôle in modern astrophysics.

In an attempt to compare properties of various stars which were claimed to be λ Bootis stars and to determine unquestionable classification criteria, it became obvious that confusion exists frequently whether a given star belongs to the group or not. When we started this project, there was not even a sample of commonly accepted λ Bootis stars available which was large enough for a sound statistical analysis of group properties. We felt it therefore necessary to define first a sample of unambiguously identified λ Bootis stars, based on a consistent and independent classification, before any further steps can be taken to increase the number of group members and to define their common properties, as well as to develop a consistent λ Bootis evolutionary theory.

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[⋆] Based on observations obtained at ESO-La Silla, CTIO, Observatoire de Haute-Provence, Osservatorio Astronomico di Padua-Asiago, Univ. Toronto Southern Observatory, Observatório do Pico dos Dias-LNA/CNPq/MCT (Brazil).

[⋆⋆] Table 1 is also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

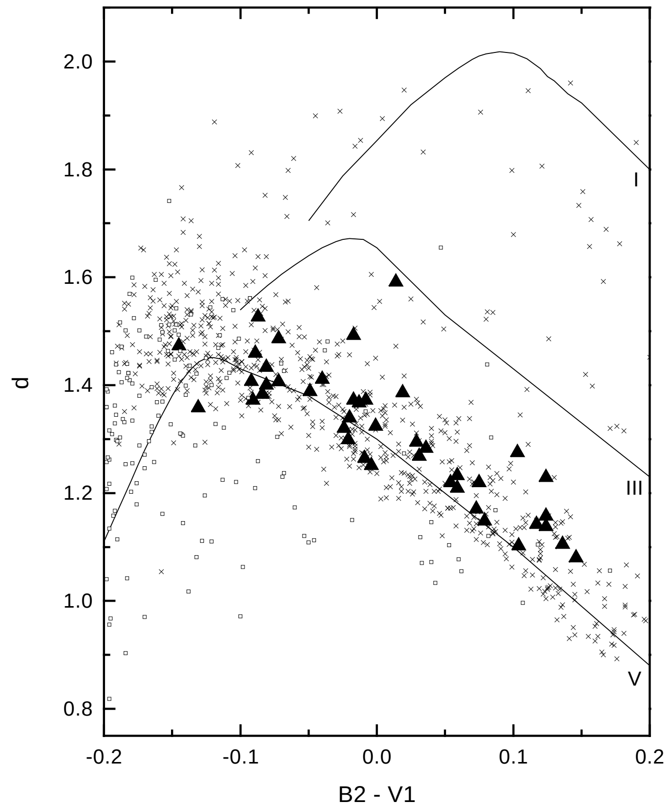

Fig. 1. $B2-V1$ versus d. The solid lines are the standard relations after Golay (1980), crosses are "normal stars" from Gray & Garrison (1987, 1989a,b), open squares are CP-stars brighter than seventh magnitude from Renson et al. (1991), filled triangles are λ Bootis stars

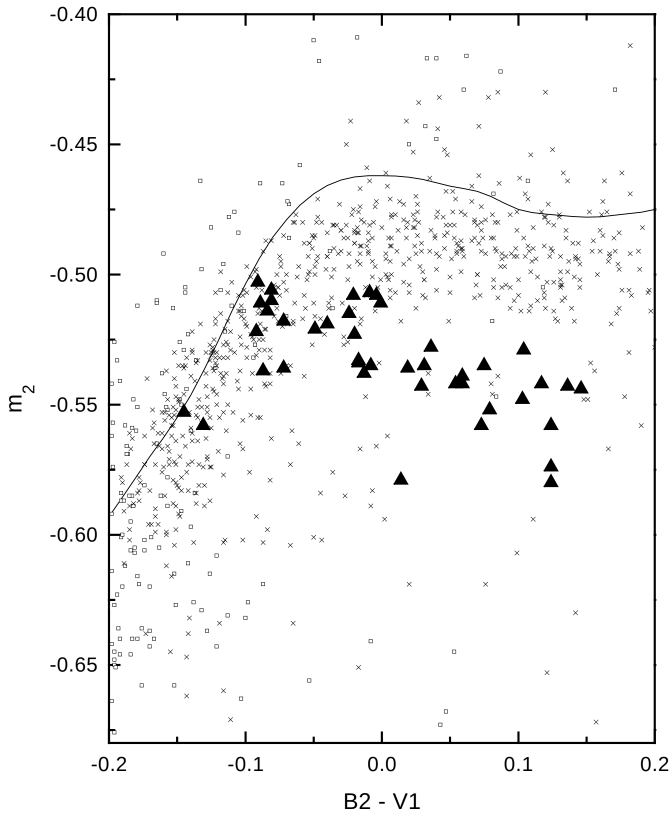

Fig. 2. $B2-V1$ versus m_2. The solid line is the standard relation after Golay (1980). Symbols are the same as in Fig. 1

2. Present status

2.1. Classification criteria

The peculiarity of λ Bootis itself was detected by Morgan et al. (1943) and soon after this classification, other stars with similar peculiarities were discovered (Slettebak 1952, 1954). Slettebak et al. (1968) also used the space velocity to distinguish λ Bootis from Population II stars as well as their "moderately large rotational velocity". Hauck & Slettebak (1983) investigated the group properties in the Geneva and Strömgren system. After the discovery of new λ Bootis stars by Abt (1984a, 1985), a list of criteria for accepting new candidates was established by Hauck (1986). Gray (1988) investigated the hydrogen-line profiles and adopted two subgroups with normal and peculiar hydrogen-line profiles. He also proposed the most recent definition for membership:

– λ Bootis stars have K and metallic-line types within a few temperature classes of A0, weak λ 4481 lines, hydrogen lines with cores typical of early to late A type stars, and broad, but often shallow wings, similar in extent to those of early A Va or Vb stars. Relative to a temperature type based on the hydrogen-line cores, the K- and metallic-line types are too early, thus the spectrum as a whole appears metal weak.
– The following classes of stars should be excluded from the λ Bootis even if they show weak λ 4481 lines: shell stars, protoshell stars, He-weak stars (easily distinguished on the basis of their hydrogen-line temperature types), and other CP stars. FHB and intermediate Population II stars may be distinguished from the λ Bootis stars on the basis of their hydrogen-line profiles. High-$v \sin i$ stars should be considered as λ Bootis candidates only if the weakening of λ 4481 is obvious with respect to standards with high values of $v \sin i$.
– The λ Bootis stars fall into two distinct classes with normal (early A-dwarf) hydrogen-line profiles (NHL), and with peculiar hydrogen-line profiles (PHL) with weak cores and broad but often shallow wings.

Baschek et al. (1984) found some strong absorption features at 1600 Å and 3040 Å in IUE spectra. These features are observed only for λ Bootis stars and were used to define new candidates. Holweger et al. (1994) identified the 1600 Å feature as a satellite in the Lyman α profile due to perturbation by neutral hydrogen. Observations in the infrared and optical region gave some evidence for gas and dust shells around λ Bootis stars (Gerbaldi & Faraggiana 1993; Bohlender & Walker 1994; Andrillat et al. 1995).
To what extent the lack of a measurable magnetic field

larger than ≈ 300 Γ (Bohlender & Landstreet 1990) is characteristic for λ Bootis stars cannot yet be assessed due to the limited number of polarimetrically investigated stars.

This brief review of the development of various classification criteria explains the present inhomogeneity of the group of λ Bootis stars. Very few of the members fulfill *all* the photometric and spectroscopic criteria including the UV, visible and IR spectral regions. But what about those candidates which match only a subset, and which criteria are unique to λ Bootis stars?

The membership problem is also reflected in the inflation of members in λ Bootis star lists. A critical analysis of candidates known in the eighties resulted in 20 entries (Gray 1988), the same number is given in Faraggiana et al. (1990). Renson et al. (1990) include already 101 λ Bootis stars in their catalogue.

For a consolidation of the catalogue we have to return to what are considered to be the intrinsic properties of λ Bootis stars: **Pop I hydrogen burning A-type stars, which are, except of C, N, O and S, metal poor**.

The degree of metal deficiency, $T_{\rm eff}$, and $\log g$ can be determined primarily by spectroscopic techniques, and in particular by time consuming abundance analyses.

2.2. Abundance analyses

The first abundance analysis was made by Burbidge & Burbidge (1956). They investigated two λ Bootis stars and found metal deficiencies by a factor of 20 relative to the Sun. Baschek & Searle (1969) reported a metal deficiency by a factor of 3 in three stars, but they found the oxygen abundance being almost normal. Venn & Lambert (1990) confirmed the previous results and added C, N, and S as near-solar abundant elements. Stürenburg (1993) analysed extensively 13 stars and he summarized the abundances pattern:

- The light elements (C, N, O and S) have a solar abundance.
- The heavier elements (Mg, Al, Ca, Fe, ...) are underabundant by up to a factor of 100.

Heiter (1996) confirmed the abundance values obtained for two stars by Venn & Lambert (1990) and by Stürenburg (1993) and extended for those two stars the list of elements with determined abundances.

2.3. Theories

Only recently, theories have been developed to explain the λ Bootis phenomenon. First, Michaud & Charland (1986) advanced a diffusion/mass-loss theory, according to which the λ Bootis stars are rather *old* and at the end of their main-sequence lifetime. Venn & Lambert (1990) argue that accretion of metal–depleted gas from the surrounding interstellar medium causes the λ Bootis phenomenon, what would result in *young* λ Bootis stars on the ZAMS. Waters et al. (1992) described a selective depletion scenario similar to post-AGB stars. Charbonneau (1991, 1993) and Turcotte & Charbonneau (1993) presented numerical calculations describing the surface and internal abundance evolution of a λ Bootis star.

Results from spectroscopy (Gray & Corbally 1993) and asteroseismology (Weiss et al. 1994) are presently inadequate to decide between these theories. The latter technique would be particularly powerful for a discrimination between evolved and unevolved stars what motivated us to perform simultaneously to our spectroscopic classification survey a photometric survey for variability which presently includes 2/3 of all catalogue members.

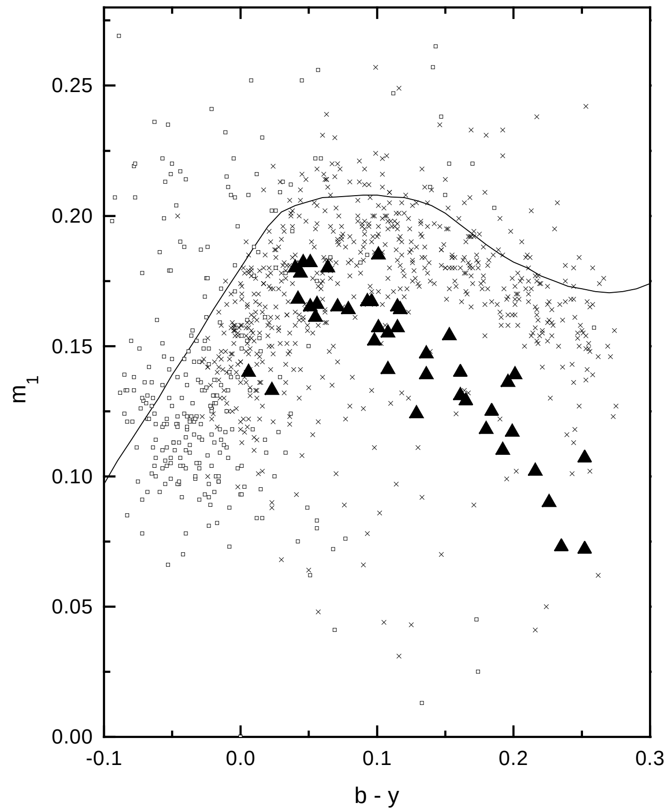

Fig. 3. $b-y$ versus m_1. The solid line is the standard relation after Philip & Egret (1980), the symbols are the same as in Fig. 1

3. The consolidated catalogue of λ Bootis stars

Our catalogue, presented in Table 1, consists of λ Bootis stars for which classification spectra were available to us or have been observed by us, and/or for which a membership to this group is confirmed by an abundance analysis.

Candidates for this catalogue were taken primarily from Renson et al. (1990) and Gray & Corbally (1993). A critical assessment of the references was performed with SIMBAD and we could include 40 stars out of the 101 entries in Renson et al. (1990). We excluded those stars

Table 1. λ Bootis stars

HD	α(2000)	δ(2000)	v sin i	V	CS	HS	UV	VAR	IR	G	S	comments
319	00 07 46.9	−22 30 31.0	60[1,6]	5.93	AB84b	ST93		PA96b		⋆	⋆	ADS, IL95
			45[5]		GR88							
					GR93							
4158	00 43 54.0	−20 23 59.3		9.54			FA90			⋆	⋆	HA83
6870	01 08 04.0	−61 52 17.9		7.50			FA90	BR79		⋆	⋆	HA86
11413	01 50 54.5	−50 12 22.0	125[1]	5.93	AB84b	ST93		WA83	⋆	⋆	⋆	IL95
			122[6]		GR88							
					GR93							
30422	04 46 25.8	−28 05 14.9	160[1]	6.18	GR93			KU96b		⋆	⋆	IL95
			100[5]									
31295	04 54 53.7	+10 09 03.3	120[1]	4.64	AB84b	BA69	BA84	KU96a	⋆	⋆	⋆	IDS, BO90
			105[5]		GR88	ST93	BA88					HA83, IL95
					GR93	VE90	FA90					
294253	05 36 41.8	−03 30 12.6		9.69	LE94					⋆	⋆	
290799	05 40 24.2	−00 46 17.4		10.63	GR93					⋆	⋆	IL95
38545	05 47 13.1	+14 29 18.4	200[1]	5.72	GR88	BO94		KU96a		⋆	⋆	BO90, IL95
			175[5]		GR93	ST93						
39421	05 52 07.7	−09 02 30.9		5.95	AB84b				⋆	⋆	⋆	
75654	08 49 52.4	−39 08 30.1		6.38				BL77		⋆	⋆	† HA86
81290	09 23 02.1	−49 03 30.8		8.88				PA96d		⋆	⋆	HA86
83041	09 34 56.6	−28 52 39.3		8.78				PA96a		⋆	⋆	HA86
84123	09 44 06.9	+42 03 06.8		6.87					⋆	⋆	⋆	† HA86
84948	09 50 05.8	+49 04 32.4		8.15	AB84a						⋆	†
98772	11 22 51.3	+64 19 49.7	170[2]	6.03	AB84b					⋆	⋆	
			230[5]									
101108	11 38 19.4	+38 45 17.0	100[2]	8.89	SL68		FA90			⋆	⋆	ADS, HA83
105058	12 05 43.4	+49 40 55.7	130[2]	8.88	SL68		BA84	NVS		⋆	⋆	HA83
							FA90					
106223	12 13 16.9	+30 16 58.5	100[2]	7.44	SL68		FA90			⋆	⋆	HA83
107233	12 19 55.3	−48 18 58.4		7.35	GR93					⋆	⋆	IL95
109738	12 37 38.1	−67 51 53.5		8.26				PA95b		⋆	⋆	HA86
110411	12 41 53.1	+10 14 08.1	170[1]	4.88	GR88	ST93	BA84	AT78	⋆	⋆	⋆	BO90
			166[6]		GR93		FA90					
					SL54							
111786	12 51 57.9	−26 44 17.5	140[1]	6.14	AN77	ST93	BA84	KU94a	⋆	⋆	⋆	BO90, HA83
			135[5]		GR88		BA88					IL95
			126[6]		GR93		FA90					
125162	14 16 23.0	+46 05 18.0	110[1,5]	4.18	GR88	BA69	BA84	PA96d	⋆	⋆	⋆	BO90, HA83
					GR93	OK67	BA88					IL95
					SL54	VE90						
141851	15 51 15.8	−03 05 24.5	140[3]	5.10	AB84b			PA96b	⋆	⋆	⋆	
			185[5]									
142703	15 56 33.4	−14 49 46.3	70[3]	6.12	GR93			PA94a	⋆	⋆	⋆	HA86, IL95
			95[5]					PA95a				
								PA96c				
142994	15 59 10.9	−38 44 54.3		7.18	GR88			PA95a		⋆	⋆	IL95
					GR93			WE94				
149303	16 31 47.2	+45 35 53.8		5.64*	AB85			PA96d	⋆	⋆	⋆	ADS
156954	17 21 00.4	−13 05 07.6		7.68	AB79			PA96d		⋆	⋆	† HA86
160928	17 44 41.9	−42 43 45.4		5.88*					⋆	⋆	⋆	† IDS, HA86
168740	18 25 31.7	−63 01 11.5	150[3]	6.14				PA95c	⋆	⋆	⋆	HA86
170680	18 31 26.3	−18 24 09.7	305[2]	5.14	AB84b		BA88		⋆	⋆	⋆	† ADS
			200[5]									
171948	18 36 37.0	+22 06 27.4		6.71	AB85			PA96d				ADS

Table 1. continued

HD	α(2000)	δ(2000)	v sin i	V	CS	HS	UV	VAR	IR	G	S	comments
177120	19 04 14.1	−22 53 46.4		6.68*	AB85					⋆		ADS
183324	19 29 01.0	+01 57 02.1	90[1,6]	5.77	GR88	HE96	BA88	KU94b		⋆	⋆	IL95
			105[5]		GR93	HO91						
						ST93						
184190	19 34 55.1	−39 47 25.0		9.81						⋆	⋆	HA86
184779	19 37 59.5	−43 54 28.3		8.90						⋆	⋆	HA86
192424	20 14 04.5	+22 13 24.6		7.08*	AB85			PA96d				ADS
192640	20 14 32.0	+36 48 22.4	80[1]	4.95	GR88	BA69	BA84	GI77	⋆	⋆	⋆	IDS, BO90
			35[5]		GR93	HE96	BA88	KS96				HA83, IL95
					SL52	OK67	FA90	PA96c				
					SL54	ST93						
						VE90						
193256	20 20 27.0	−29 11 28.9	240[1,6]	7.70	GR88	HO91		PA96b	⋆	⋆	⋆	ADS
					GR93	ST93						IL95
193281	20 20 27.9	−29 11 50.0	90[1]	6.61	GR88	HO91		PA96b	⋆	⋆	⋆	ADS
			75[5]		GR93	ST93						IL95
			83[6]									
198160	20 51 38.8	−62 25 45.4	200[4]	5.65*	GR88	HO91			⋆	⋆	⋆	IDS, IL95
			175[6]		GR93	ST93						
204041	21 25 51.5	+00 32 03.7	70[1]	6.45	GR88	HO91		PA96b	⋆	⋆	⋆	BO90, IL95
			65[6]		GR93	ST93						
210111	22 08 42.7	−33 07 32.9	60[1]	6.34	GR88	HO91		PA94b	⋆	⋆	⋆	HA86, IL95
			55[5,6]		GR93	ST93						
221756	23 34 37.5	+40 14 11.2	100[1]	5.59	GR88	ST93	BA88	PA96a	⋆	⋆	⋆	BO90, IL95
			75[5]		GR93			RU82				

v sin i.... [1] Gray & Corbally (1993), [2] Uesugi & Fukuda (1982), [3] North et al. (1994), [4] Stürenburg (1993), [5] Abt & Morrell (1995), [6] Holweger & Rentzsch-Holm (1995)

V........ mag(V): Mermilliod & Mermilliod (1994) CS.. classification spectroscopy available

HS....... high resolution spectroscopy available UV.. UV observations available

VAR..... survey for photometric variability IR... infrared observations available (King 1994)

G........ Geneva colours available (Table 2) S.... Strömgren colours available (Table 3)

comments: BO90...check for magnetic field, IL95...comment on evolutionary status, ADS/IDS...binary catalogue entry, HA83, HA86...candidate proposed by Hauck & Slettebak (1983) and Hauck (1986), †...present spectroscopic classification survey with following remarks:

HD 75654: Mg II lines too weak for spectral type
HD 84123: metal lines are too weak relative to Balmer lines which indicate F0-F2
HD 84948: similar to HD 84123
HD 156954: Mg II too weak, otherwise normal metal spectrum
HD 160928: similar to HD 156954
HD 170680: photometry indicates a temperature which is too high for the spectral type, but blend at 4481 Å is definitely Mg II and not He, very high v sin i

*......... combined magnitudes and photometric indices for close binary systems

AA##a: References (A, a...letter, #...number) can be found bold–faced in the bibliography.

classified by Gray & Garrison (1987, 1989a,b) as non-λ Bootis stars. For more details see Sect. 4.

Unfortunately, there are still some measurements for λ Bootis stars missing in our catalogue, especially in the ultraviolet. Nevertheless, we tried to extract those properties which are common to all catalogue stars and which seem to be significant for the λ Bootis phenomenon. But still, there remains a chance of confusion with somehow phenomenologically related stars, like Be, He-weak and Horizontal Branch stars. The ultimate membership criterium would result from a spectroscopic analysis concerning abundances, $T_{\rm eff}$ and $\log g$, but which is time consuming. The present catalogue can provide a selection of high probability λ Bootis stars for such an investigation. In conclusion, for accepting a candidate for our catalogue we used the following partially redundant criteria, of which all of them have to be fulfilled by a member, provided that the necessary observations were available:

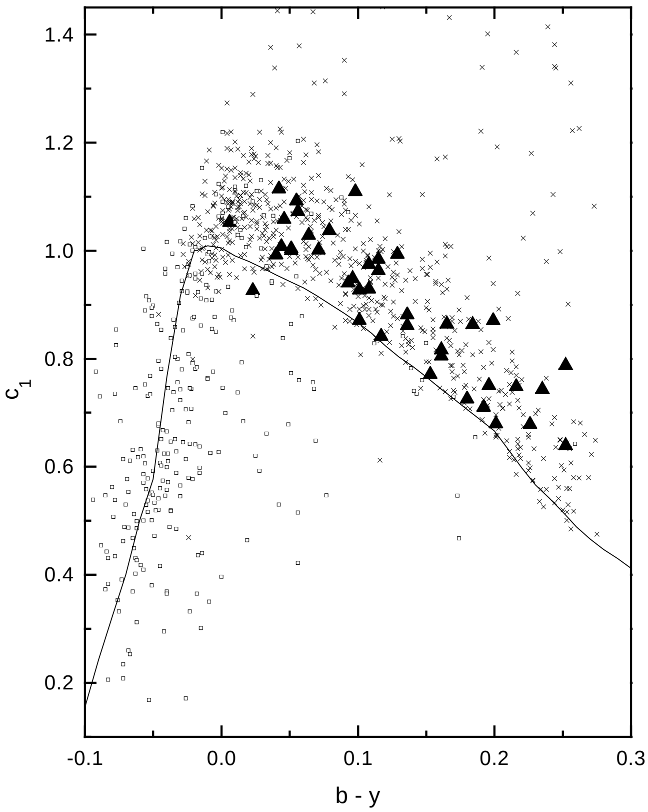

Fig. 4. $b-y$ versus c_1. The solid line is the standard relation after Philip & Egret (1980). Symbols are the same as in Fig. 1

– The metallic line spectrum is too weak for the spectral type derived from the hydrogen lines
– $\log g$ consistent with Main Sequence
– Geneva and Strömgren photometric indices within the parameter space as is evident in Figs. 1 to 5
– Strong absorption features at 1600 Å and 3040 Å
– Negative Δa-values
– λ Bootis abundance pattern (see Sect. 2.2).

4. Rejected candidates

The catalogue from Renson et al. (1990) lists 101 candidate stars. On the grounds of recent publications we could identify 37 stars as misclassified, 26 of them had already an uncertain or misclassification as λ Bootis stars in Renson et al. (1990). In addition, the following entries were classified as λ Bootis stars by Abt (1984a,b), Hauck (1986), and Levato et al. (1994), but were not included in our catalogue for the following reasons:

– *No λ Bootis character in the ultraviolet* (Baschek et al. 1984; Faraggiana et al. 1990):
HD 22470, HD 34787, HD 39283, HD 79469, HD 80081, HD 169022, HD 187949, HD 188728, HD 212061, HD 217782.
– *New classification as non–λ Bootis stars*
- by Gray & Garrison (1987, 1989b):
HD 16811, HD 16955, HD 21335, HD 56405, HD 98353, HD 123299, HD 161868, HD 172167, HD 210418, HD 220061, HD 220278
- by other authors:
HD 11905: B8 HgMn (Ptitsyn & Ryabchikova 1986)
HD 24712: roAp (Kurtz et al. 1989)
HD 78316: B8 HgMn (Adelman 1992)
HD 78661: F2 V (Cowley & Bidelman 1979)
HD 89353: post-AGB star (van Winckel et al. 1995)
HD 97411: B9 V (Edwards 1976)
HD 97937: evolved star (Gray 1989)
HD 128167: F2 V (Gerbaldi et al. 1995)
HD 130158: evolved star (Gray 1988)
HD 154153: evolved star (Gray 1989)
HD 204965: Geneva and Strömgren photometry indicate that this star is a FHB or Giant star
HD 222303: cool star ($b-y = 0.414$, $m_1 = 0.064$ and $c_1 = 1.117$)
- by the present survey:
HD 6173: A0 IIIn
HD 37886: B8 III
HD 79108: A0Van
HD 81104: A3 IV.

5. Discussion

The purpose of this consolidated catalogue of 45 stars is to establish an as large as possible group of λ Bootis stars with high membership probability. Based on this catalogue, we derive photometric and spectroscopic parameter values which shall help to successfully preselect candidates for a spectroscopic survey of field and cluster candidates in order to increase the number of known λ Bootis stars. An efficient preselection of candidates is absolutely necessary for telescope time consuming surveys. In an iteration, the extended list of members shall provide us with a sample of unquestionable λ Bootis stars which is large enough for a sound statistical analysis of the group properties. This knowledge has to be well established prior to any attempt to develop theories concerning the λ Bootis phenomenon.

5.1. Photometry

Narrow band photometry has often been used to distinguish chemically peculiar from normal stars. The Geneva (Figs. 1 and 2) and Strömgren (Figs. 3, 4 and 5) photometric systems provide estimates for temperature, surface gravity and chemical composition of stars. However, we have to stress again that these calibrations were derived for *normal* abundant stars. We conclude from the figures mentioned:

– *Metallicity:* All members have a low metallicity which decreases with temperature. A photometric parameter space which includes all our catalogue stars is well determined.

– *Temperature:* The temperature ranges from early AV to early FV stars.
– *Surface gravity:* λ Bootis stars cannot be distinguished from normal dwarf stars.
– *Confusion with non-λ Bootis stars:* As is also obvious from the figures, other stars populate the same parameter space. An unambiguous detection of λ Bootis stars with standard photometry alone is impossible, although to some extend a discrimination with metallicity sensitive indices is useful. But such attempts have led in the past to many spurious entries in various catalogues and in a confusion of the subject.

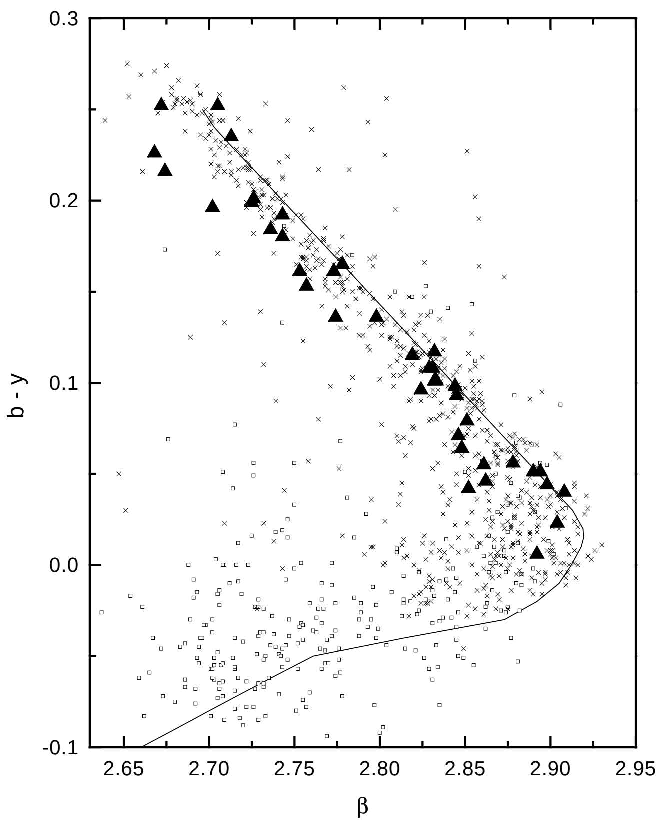

Fig. 5. β versus $b-y$. The solid line is the standard relation after Philip & Egret (1980). Symbols are the same as in Fig. 1

Parallel to the photometric observations needed for the colour indices, we investigated also the photometric stability of our catalogue stars which is reflected by the column "VAR" in Table 1. For nearly 50% of investigated catalogue members we found definite indications for a variability in time scales which are typical for pulsating δ Scuti stars. This high incidence of rather large amplitude multifrequency pulsation makes asteroseismic techniques an interesting tool for investigating the structure of these stars.

5.2. Rotational velocity

Several authors (Gray & Corbally 1993, and references therein) used the rotational velocity as additional criterium for λ Bootis stars. These authors suggest that only stars with $v \sin i > 50$ km s^{-1} should be included to this group. We therefore investigated the rotational velocity distribution of normal A0V to F0V stars from Gray & Garrison (1987, 1989a,b) with $v \sin i$ values taken from the catalogue of Uesugi & Fukuda (1982). In addition, we considered all stars from the Michigan Spectral Catalogue (Houk & Cowley 1975; Houk 1978, 1982; Houk & Smith-Moore 1988) within the relevant spectral classes.
The distribution of $v \sin i$ –values for normal stars (Fig. 6) is in good agreement with the literature (Abt & Morrell 1995). The distribution for λ Bootis stars (Fig. 6) is similar to that for normal stars, but no λ Bootis star is presently known with $v \sin i < 50$ km s^{-1}. To what extend this distribution is intrinsic or distorted by small number statistics remains open. We are not able to rule out measurement errors due to the weakness of the spectral lines and a bias due to the $v \sin i$ "classification criterion". We suggest therefore to drop the $v \sin i$ membership criterion.

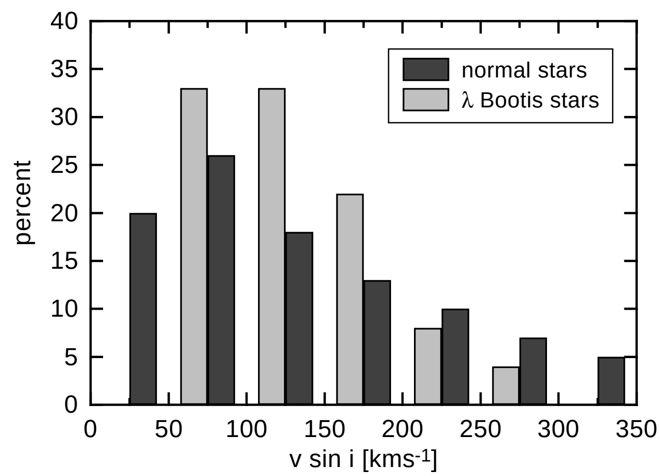

Fig. 6. Rotational velocity distribution for stars from A0 to F0 from Gray & Garrison (1987, 1989a,b) and the Michigan Spectral Catalogue (Houk & Cowley 1975; Houk 1978, 1982; Houk & Smith-Moore 1988), $v \sin i$ values from Uesugi & Fukuda (1982). Rotational velocity distribution for all λ Bootis stars in this catalogue

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Table 2. Geneva colours from the Geneva database, * combined magnitudes for close binary systems

HD	*B2-V1*	*d*	Δ	*g*	m_2	*P*
319	−0.040	1.411	0.523	0.089	−0.519	5
4158	0.124	1.229	0.182	0.010	−0.580	3
6870	0.059	1.209	0.257	0.052	−0.542	8
11413	−0.017	1.372	0.444	0.070	−0.534	392
30422	−0.009	1.264	0.405	0.101	−0.507	4
31295	−0.091	1.372	0.524	0.108	−0.503	3
290799	−0.004	1.251	0.383	0.090	−0.508	2
294253	−0.131	1.358	0.383	0.063	−0.558	4
38545	−0.087	1.526	0.588	0.062	−0.537	4
39421	−0.072	1.486	0.552	0.066	−0.536	4
75654	0.059	1.232	0.288	0.058	−0.539	3
81290	0.146	1.080	0.113	0.035	−0.544	3
83041	0.124	1.157	0.165	0.034	−0.558	3
84123	0.117	1.142	0.179	0.038	−0.542	3
98772	−0.081	1.433	0.554	0.077	−0.510	0
101108	-−0.001	1.324	0.446	0.082	−0.511	2
105058	−0.008	1.372	0.438	0.064	−0.535	4
106223	0.124	1.138	0.103	0.012	−0.574	4
107233	0.079	1.148	0.169	0.040	−0.552	2
109738	0.036	1.283	0.363	0.065	−0.528	3
110411	−0.092	1.407	0.525	0.109	−0.522	29
111786	0.054	1.219	0.270	0.057	−0.542	3
125162	−0.081	1.400	0.546	0.106	−0.506	2
141851	−0.049	1.388	0.491	0.079	−0.521	6
142703	0.073	1.170	0.178	0.037	−0.558	52
142994	0.103	1.275	0.299	0.032	−0.548	3
149303*	−0.072	1.406	0.509	0.072	−0.518	1
156954	0.104	1.102	0.168	0.044	−0.529	3
160928*	−0.020	1.339	0.428	0.064	−0.523	4
168740	0.029	1.294	0.340	0.054	−0.543	4
170680	−0.145	1.473	0.506	0.060	−0.553	3
177120*	0.014	1.591	0.543	0.008	−0.579	1
183324	−0.084	1.383	0.514	0.103	−0.514	5
184190	0.136	1.105	0.141	0.037	−0.543	2
184779	0.075	1.219	0.278	0.051	−0.535	5
192640	−0.013	1.367	0.434	0.073	−0.538	1
193256	0.019	1.386	0.446	0.055	−0.536	2
193281	−0.017	1.492	0.561	0.063	−0.533	5
198160*	−0.021	1.299	0.431	0.091	−0.508	4
204041	−0.024	1.320	0.442	0.094	−0.515	3
210111	0.031	1.268	0.332	0.060	−0.535	219
221756	−0.089	1.459	0.595	0.105	−0.511	5

Table 3. Strömgren colours from Hauck & Mermilliod (1990) and Handler (1995), Δ*a*-photometry from Maitzen & Pavlovski (1989a,b), * combined magnitudes for close binary systems

HD	$b-y$	m_1	c_1	β	Δa
319	0.079	0.164	1.037	2.851	−0.010
4158	0.216	0.102	0.748	2.674	−0.037
6870	0.153	0.154	0.771	2.757	−0.018
11413	0.108	0.141	0.974	2.829	−0.021
30422	0.101	0.185	0.871	2.832	
31295	0.044	0.178	1.007	2.898	−0.015
290799	0.117	0.164	0.841	2.832	
294253	0.023	0.133	0.926	2.904	
38545	0.042	0.168	1.114	2.852	−0.005
39421	0.055	0.161	1.092	2.861	−0.013
75654	0.161	0.140	0.816	2.753	−0.016
81290	0.252	0.107	0.639	2.672	−0.023
83041	0.252	0.072	0.787	2.705	−0.035
84123	0.235	0.073	0.743	2.713	
84948	0.196	0.136	0.750	2.702	−0.017
98772	0.046	0.182	1.058	2.862	
101108	0.115	0.157	0.963		−0.013
105058	0.129	0.124	0.993		−0.017
106223	0.226	0.090	0.678	2.668	−0.024
107233	0.192	0.110	0.710	2.743	
109738	0.165	0.129	0.864	2.778	−0.026
110411	0.040	0.180	0.992	2.908	−0.017
111786	0.161	0.131	0.805	2.773	−0.027
125162	0.051	0.182	1.000	2.894	
141851	0.071	0.165	1.001	2.846	
142703	0.180	0.118	0.725	2.743	
142994	0.199	0.117	0.870	2.725	
149303*	0.064	0.180	1.028	2.848	
156954	0.201	0.139	0.679	2.726	
160928*	0.096	0.167	0.948	2.824	
168740	0.136	0.139	0.881	2.798	
170680	0.006	0.140	1.052	2.892	
183324	0.051	0.165	1.003	2.890	−0.013
184190				2.740	
184779	0.184	0.125	0.863	2.736	
192640	0.101	0.157	0.927	2.833	−0.020
193256	0.115	0.165	0.984	2.819	
193281	0.098	0.152	1.109	2.844	
198160*	0.108	0.155	0.929	2.831	
204041	0.093	0.167	0.940	2.845	
210111	0.136	0.147	0.861	2.774	
221756	0.056	0.166	1.072	2.878	−0.010

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