CHEMICALLY PECULIAR STAR π^1 BOO - STELLAR PARAMETERS AND V.SIN I

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ABSTRACT. Using the authors' own spectroscopic and published photometric observations, the atmospheric and stellar parameters of the Hg-Mn star π^1 Boo were determined. The synthetic spectrum was computed for selected part of its spectrum and compared with the observed. The following values were determined: T_{ef} = 13 160 K, log g = 2.05 (SI), M = 3.8 $M_\odot$, R = 2.8 $R_\odot$, log N_e = 14.0, v.sin i = 19 km s^{-1}. The spectral lines were identified and equivalent widths measured.

ХИМИЧЕСКИ ПЕКУЛЯРНАЯ ЗВЕЗДА π^1 BOO – ЗВЕЗДНЫЕ ПАРАМЕТРЫ И V.SIN I. На основе наших спектроскопических и напечатанных фотометрических наблюдений мы нашли атмосферические и звездные параметры Hg-Mn звезды π^1Boo. Для избранных участков спектра был вычислен синтетический спектр и сравнен с наблюденным. Были определенны следующие величины: T_{ef} = 13 160 K, log g = 2.05 (SI), M = 3.8 $M_\odot$, R = 2.8 $R_\odot$, log N_e = 14.0, v.sin i = 19 км.c^{-1}. Сделанна идентификация спектральных линий и измеренны эквивалентные ширины.

CHEMICKY PEKULIÁRNA HVIEZDA π^1 BOO - HVIEZDNE PARAMETRE A V.SIN I. Na základe vlastných spektroskopických a publikovaných fotometrických pozorovaní boli určené atmosférické a hviezdne parametre Hg-Mn hviezdy π^1Boo. Pre vybrané oblasti spektra bolo vypočítané syntetické spektrum a porovnané s pozorovaným. Boli určené tieto hodnoty: T_{ef}= 13 160 K, log g = 2.05 (SI) M = 3.8 $M_\odot$, R = 2.8 $R_\odot$, log N_e= 14.0, v.sin i = 19 km.s^{-1}. Bola urobená identifikácia spektrálnych čiar a zmerané ekvivalentné šírky.

1. INTRODUCTION

The chemically peculiar B-star ι^1Boo (HR 5475, HD 129174, GC 19769, m_v= 4.94, Sp Ap, according to Hoffleit, 1964) was first classified by Osawa (1965) and later by Cowley et al. (1969), identically as B9p Hg-Mn. A number of authors determined its effective temperature and surface gravity arriving at values ranging from 12 640 to 14 000 K for T_{ef} and 1.2 - 2.0 (SI) for log g. Palmer et al. (1968) determined the value of the rotational velocity, v.sin i, as 60 km s^{-1} from the Ca II - K line, and Preston (1978) as 16 km s^{-1} from the Mg II line 448.1 nm. Montgomery and Aller (1969) identified the spectral lines with equivalent widths and carried out a detailed analysis.

Since the published values of the surface gravity indicate a wide range, from a giant to a main-sequence star, and the value of the rotational velocity determined from two different lines differs by a factor of 4, in this paper we used our own spetroscopy and published photometric data to derive the stellar and atmospheric parameters and the value of the projected rotational velocity. Besides this, we are publishing the identification and equivalent widths of spectral lines as measured on our spectrograms.

2. OBSERVATIONAL MATERIAL, REDUCTION AND IDENTIFICATION

For the purposes of this study, two spectrograms were obtained in the blue part of the spectrum using the coude spectrograph of the 2-m telescope of the Astronomical Institute of the Czechoslovak Academy of Sciences in Ondřejov. The relevant data are given in the following table:

Plate	Date	Exposure	Emulsion	Rec.disp.
Cd 3279	1979, May 20	60 mins	Kodak IIaO	.85 nm/mm
Cd 3929	1981, Feb. 2	47 mins	Kodak IIaOb	.85 nm/mm

An Abbé comparator with scanning of the profile and laser interferometer was used to measure plate Cd 3929, and its intensity record was made with an intensity microphotometer. Both of this devices were developed in the Astronomical Institute in Tatranská Lomnica. The spectral lines were identified with the aid of the tables of Moore (1945), Wright et al. (1964), and Kurucz and Peytremann (1975). In the intervals of 402 - 415 nm, 423 - 433 nm and 450 - 459 nm the identification was also made with the aid of the theoretical synthetic spectrum computed using Hubený's (1986) SYNSPEC program for elements up to Z = 30 (Zn). The identification and measured equivalent widths are given in Tab.I: the first column gives the table wavelengths after Kurucz and Peytremann (1975), the second the identification and the third the equivalent widths in picometres. Uncertain identification is indicated by a question mark, blends by parentheses.

3. STELLAR AND ATMOSPHERIC PARAMETERS

The atmospheric and stellar parameters T_{ef}, log g, mass, radius, luminosity and bolometric stellar magnitude can be derived from photometric systems calibrated on the basis of observations and theoretical models related to the separate parameters. In the following we shall use observations in uvbyβ, UBV, the Geneva photometric system, and the comparison of the theoretical and observed Hβ and Hδ -lines to derive these parameters.

The uvbyβ system: Based on Cameron's photometry Philip et al. (1976) give the following values:

$$(u - b)_0 = .677 \qquad (b - y)_0 = -.057$$
$$m_0 = .089 \qquad c_0 = .613$$
$$E(b - y) = .049 \qquad = 2.745$$
$$[u - b] = 2(b - y) + 2m_1 + c_1 = .782$$

These indeces and Philip's and Newel's calibration (1975), $\Theta_{ef} = 0.202[u - b] + 0.196$, were used to derive the value $\Theta_{ef} = 0.354$, which corresponds to T_{ef} = 14 240 K. Drawing on Zabriskie's calibration (1977) of this photometric system, we arrived at T_{ef} = 13 490 K and log g = 2.13 (SI). Palmer's calibration (1977), based on theoretical models, yields T_{ef} = 13 400 K. Osmer and Peterson (1974) derived the relation $\Theta_{ef} = 0.156 + 0.262[u - b]$, and this yields T_{ef} = 13 970 K. Using this calibration, Cowley and Aikman (1975) estimated T_{ef} = 12 640 K, but they used colour indices affected by the light of Am star HD 129 175 at a distance of 6". By comparing indices c_0 and m_0 with the theoretical values calculated by Releya and Kurucz (1978), Boesgaard et al. (1982) arrived at T_{ef} = 13 000 K and log g = 1.2. Using the same method Guthrie (1984) obtained T_{ef} = 12 900 K and log g = 1.8. If we disregard the value affected by the light of the close star, T_{ef} = 12 640 K, we arrive at the average value of the effective temperature derived from uvby photometry

$$T_{ef} = 13\,500 \pm 220 \text{ K}.$$

Similarly the average value of the surface gravity in SI units comes out as

$$\log g = 2.0 \pm 0.2,$$

if the value of Boesgaard et al. (1982) is disregarded, being more appropria-

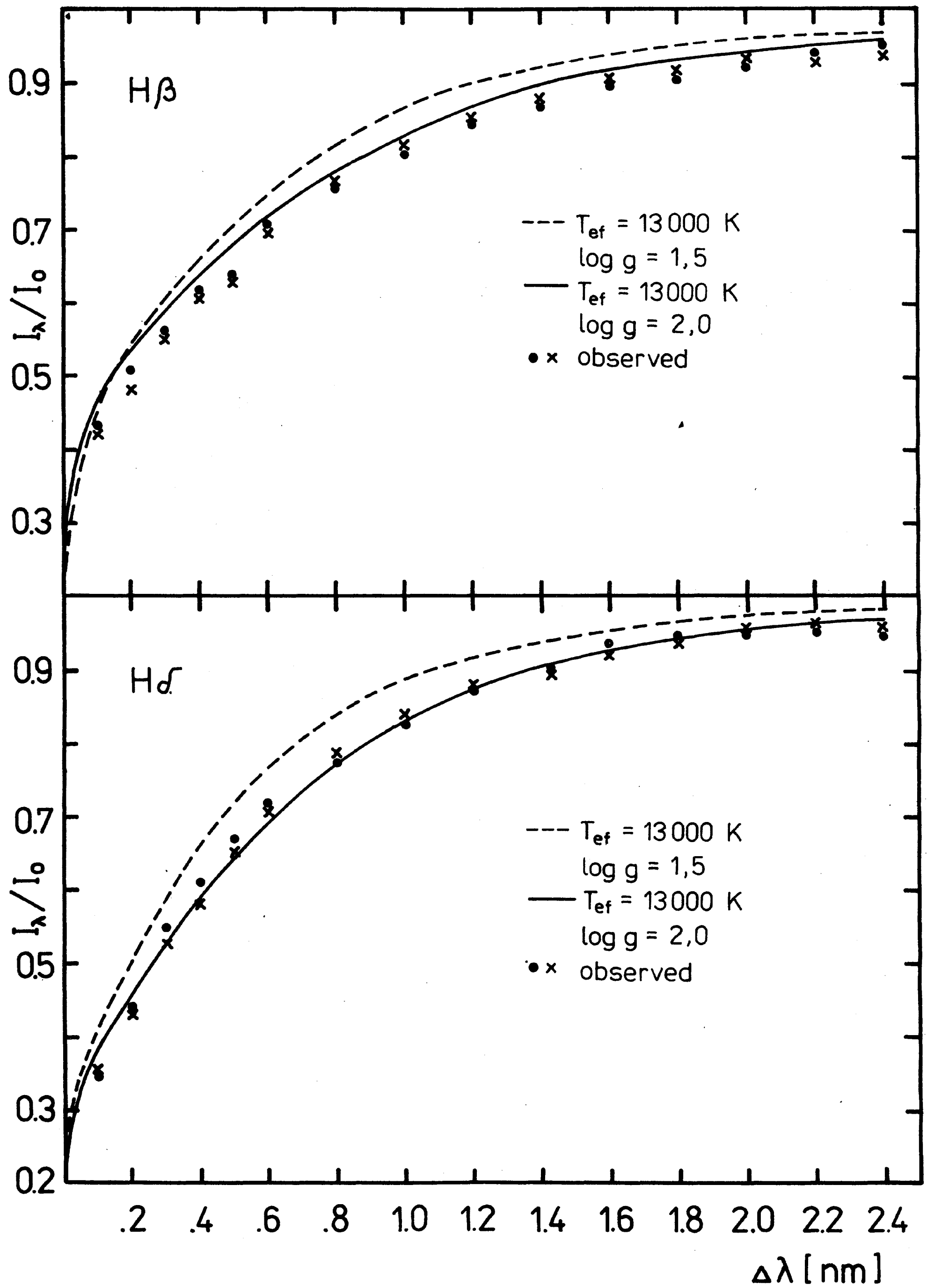

Fig. 1. Comparison of the observed and theoretical profiles of the Balmer lines Hβ and Hδ.

te to a giant than a main-sequence star.

The UBV system: Blanco et al. (1968) give the following values of the indices in the UBV photometric system:

$$B - V = -.02 \qquad U - B = -.33$$

However, these values have not been corrected for interstellar reddening. Crawford used the following relations for calculating the reddening: $A = 3.2E(B - V)$ and $A = 4.3E(b - y)$. The uvby photometry yields the value $E(b - y) = 0.049$, and this in turn $E(B - V) = 0.066$. For B1V - A0V stars, according to Heintze (1973), $E(U - B) = 0.645E(B - V)$, and consequently $E(U - B) = 0.043$. The colour indices corrected for reddening are then

$$(B - V)_0 = -0.086 \quad (U - B)_0 = -0.373.$$

According to Heintze (1973), $Q = (U - B) - 0.645(B - V) = -0.3175$ and, according to Hyland's relation $\Theta_{ef} = 0.406Q + 0.51 = 0.3811$, and $T_{ef} = 13\,220$ K. Also, according to Hyland's calibration (1969), $\Theta_{ef} = 0.3145(U - B) + 0.513 = 0.396$, and $T_{ef} = 12\,740$ K; Heintze's calibration (1969) yields $\Theta_{ef} = 0.306(U - B) + 0.507 = 0.393$ and $T_{ef} = 12\,830$ K. Schield et al. (1971) arrived at $\Theta_{ef} = 0.3045(U - B) + 0.502 = 0.388$ and $T_{ef} = 12\,980$ K. The average value of the effective temperature derived from UBV photometry is

$$T_{ef} = 12\,940 \pm 105 \text{ K}.$$

As regards the value of the surface gravity, Gray (1976) gives the relation $\log g = 2.17 + 0.38(B - V)$, this comes out as

$$\log g = 2.14.$$

The Geneva photometric system: Rufener (1980) gives the values for π^1 Boo. Cramer's and Maeder's calibration (1979) yields the effective temperature

$$T_{ef} = 12\,700 \text{ K}.$$

By comparing the observed profile of the hydrogen line Hδ with theoretical profiles derived from Kurucz's models (1978) we obtain the following values:

$$T_{ef} = 13\,000 \text{ K} \quad \text{and} \quad \log g = 2.0$$

These values agree well with the observed He I line 402.6 nm.

The following table is a review of the values of derived effective temperatures. The symbol n stands for the number of determinations from independent calibrations which were also used as weigths in determining the average:

uvbyβ system	T_{ef} = 13 500 K	n = 5
UBV system	12 940	4
Geneva system	12 700	1
Theor. spectrum	13 000	2
Average	T_{ef} = 13 160 K $\pm$ 220 K	

The value of the surface gravity can be derived from the relation $g_* = g_\odot M_*/M_\odot (R_\odot/R_*)^2$ provided the absolute bolometric magnitude of the star is known, since $\log R_*/R_\odot = \frac{1}{2} \log L_*/L_\odot - 2 \log T^*_{ef}/T^\odot_{ef}$, the mass ratio $\log M_*/M_\odot = -0.1\, M^*_{bol} + 0.47$ (Schmidt-Kaler, 1965) and $\log L_*/L_\odot = 0.4(M^\odot_{bol} - M^*_{bol})$.

The relation $M_V = m_V + 5 + 5 \log \pi - A$ yields $M_V = -0.499$ if $m_V = 4.94$ and π = 0.009" after Bečvář (1964), and A = 0.21 according to the calculations of interstellar reddening given above. Philip et al. (1976) arrived at the value $M_V = 0.05$. According to Egret´s calibration (1978), $M_V(\beta) = -\exp(-7.331\beta + 20.861) + 2.0 = -0.091 \pm 0.06$. For the equivalent width Hβ = 0.891 pm, Balona´s and Crampton´s calibration (1974) yields $M_V(\beta, \gamma) = -0.51 \pm 0.3$. Cramer´s and Maeder´s calibration (1979) of the Geneva photometric system leads to $M_V = -0.069$ according to Rufener (1980). The average value of five estimates is $M_V = -0.22 \pm 0.3$. According to Allen (1976), the bolometric correction for T_{ef} = 13 160 K is BC = -0.895, so that $M_{bol} = -1.12$, $M_*/M_\odot = 3.82$ and $L_*/L_\odot = 223$. Using $\log g_\odot = 2.438$ and $T^\odot_{ef}$ = 5770 K (Allen, 1976) we obtain $\log g_* = 2.10$. The average value of all estimates:

from uvby	$\log g_*$ = 1.96
UBV	2.14
Sp.	2.00
M_{bol}	2.10
Mean	$\log g_*$ = 2.05 $\pm$ 0.04

The average value of the electron concentration can also be derived from the available observational material. The Inglis-Teller relation, $\log N_e = 23.26 - 7.5 \log n$, yields $\log N_e = 13.84$, if the last visible line of the Balmer series H_{17} is considered. The value of the electron concentration can be derived from the equivalent widths of lines Hγ and Hδ of the Balmer series by using the relations

$$\log N_{0,2}H = 16.86 - ((1 - 10^{-D})^{-1} - R_c^{-1}),$$
$$W_\lambda^{5/2} = K\, N_{0,2}H\, (R_c/0.45)\, N_e$$

(Kopylov, 1961); $N_{0,2}H$ is the number of atoms excited to the second level, D the value of Balmer´s jump, R_c the maximum central depth of the spectral line, W_λ the equivalent width of the appropriate line, K = -29.10 and -29.18 is a constant for Hγ and Hδ ,respectively.

The value of Balmer's jump from direct observations is not known, but it can be derived from photometry. For the UBV system, Belyakina and Chugajnov (1960) give the relation D = 0.53 + 0.55 Q, where Q is the parameter already mentioned above; if Q = -0.3175, D = 0.355. Böhm-Vitense (1965) gives the formula D = 0.487 + 0.494(U - B) - 0.392(B - V), and this in turn yields D = 0.336. In uvby photometry, the index of Balmer's jump in the dependence of c_1- D can be used to estimate D: D = 0.321 (Zverko, 1975). The average value of three estimates is D = 0.34 ± 0.03. For $H\gamma$ this yields $\log N_{0,2}H$ = = 17.126 and $\log N_e$ = 14.02, and for $H\delta$ $\log N_{0,2}H$ = 17.068 and $\log N_e$ = 14.26. The mean value of the average electron concentration $\log N_e$ = 14.0 ± 0.2.

The projected rotational velocity v sin i was determined by Palmer et al. (1968) on low-dispersion spectrograms by estimating from Ca II - K line. They came out with v sin i = 60 $km.s^{-1}$. However, Wolff and Preston (1978), using numerous metal lines, derived the value v sin i = 16 km s^{-1}. Slettebak et al. (1975) developed a system of standard stars for determining rotational velocities from the halfwidth of the Mg II line 448.13 nm. For the B7V - A3V stars we derived the relation

$$v \sin i = -27.0 + 617 \text{ HW km s}^{-1},$$

where HW is the half-width of the Mg II line in nm; if HW = 0.074 nm, v sin i = 19 ± 5 km s^{-1}. The K-line of calcium is similarly narrow as the magnesium line considered above, but at the low dispersion (12 nm mm^{-1}) used by Palmer et al. (1968) the strengthened lines of manganese 393.095 and possibly 394.1277 and 394.3860 nm could have affected the estimate of the width of the K-line to make it higher.

4. CONCLUSIONS

The atmospheric and stellar parameters of the Hg-Mn star π^1Boo were determined from spectroscopic and published photometric data. We have made use of measurements in three photometric systems, uvbyβ, UBV and the Geneva system, several independent calibrations in the first two systems being used to determine the temperature and surface gravity. The spectral data were used to compare the theoretical and observed profiles of Balmer lines Hβ and Hδ, and as regards the helium lines 402.6 and 447.1 nm, which are sensitive indicators of temperature in the neighbourhood of late B-stars, sections of the synthetic spectrum were computed. The average resultant values are:

$$T_{ef} = 13\,160 \text{ K}, \log g = 2.05 \pm 0.04 \text{ (SI)}.$$

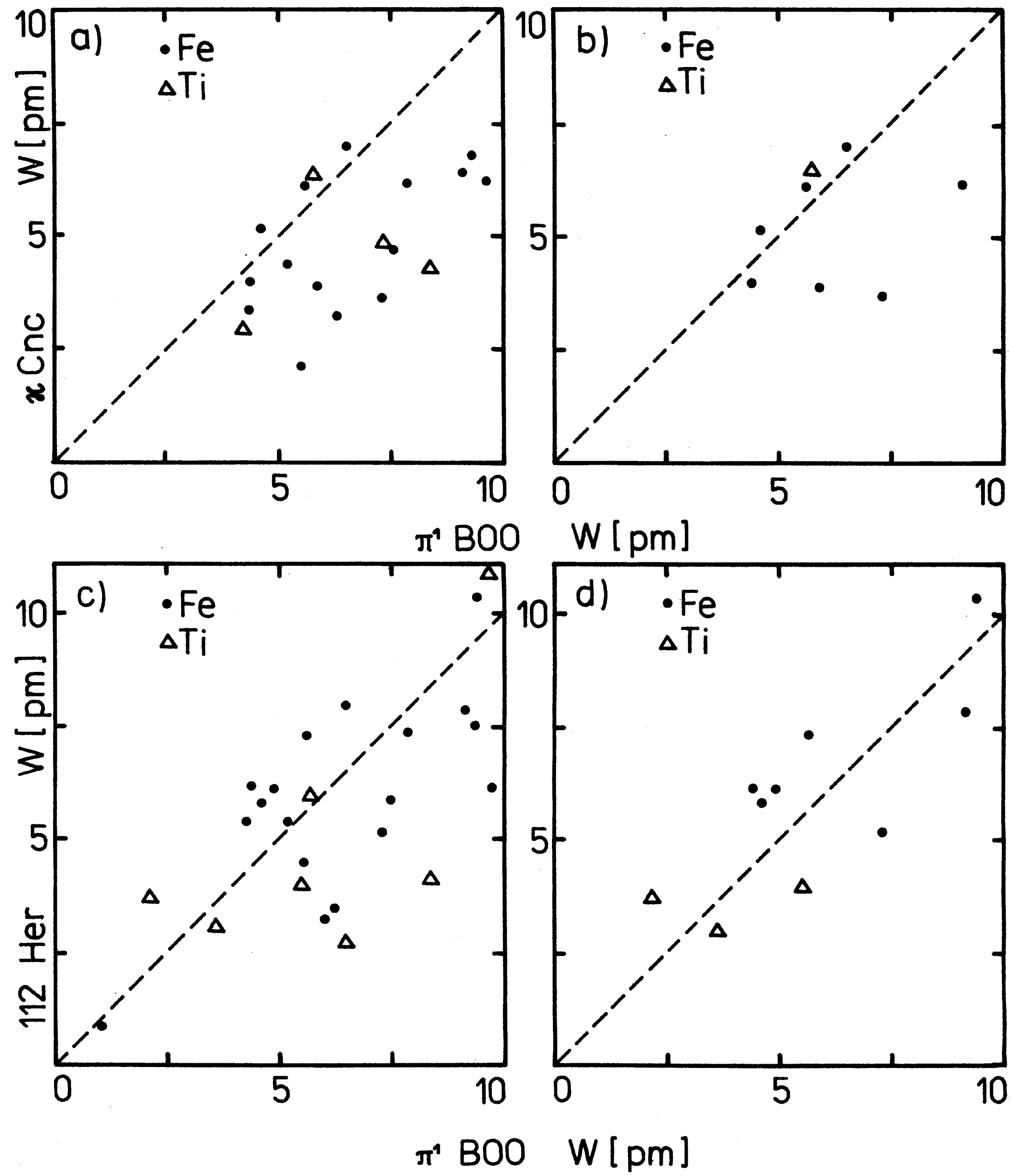

Fig. 2. Comparison of equivalent widths of selected lines.

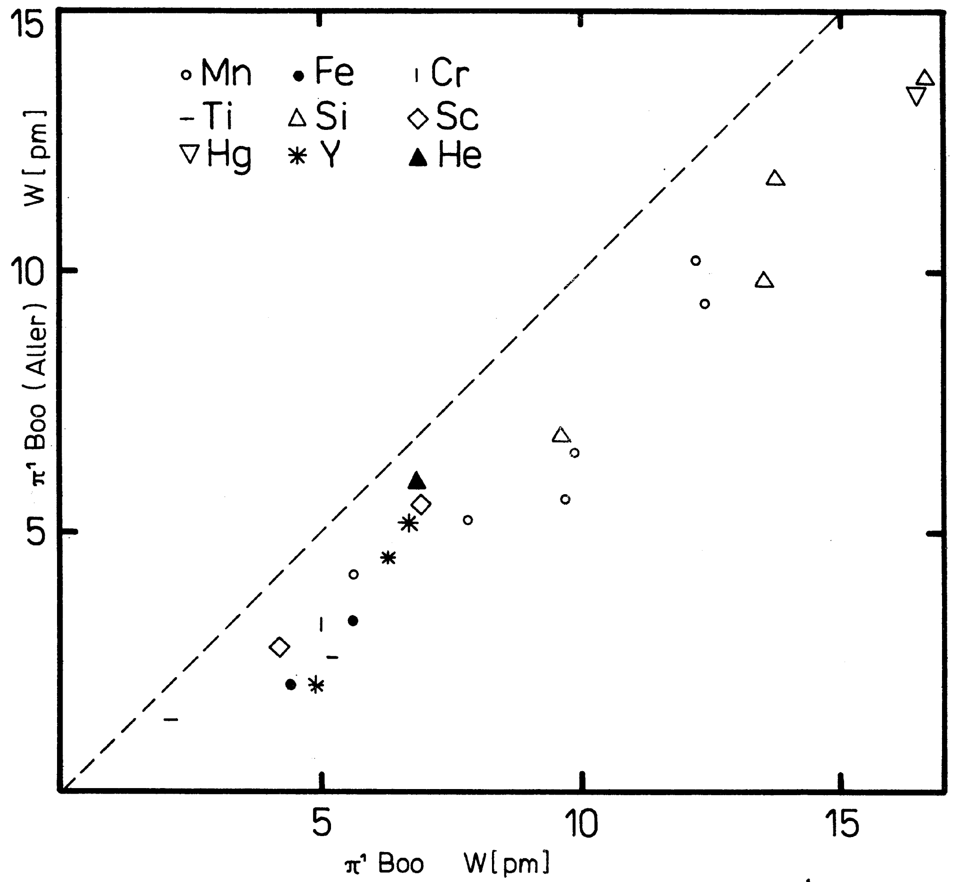

Fig. 3. Comparison of equivalent widths of selected lines in π[1] Boo.

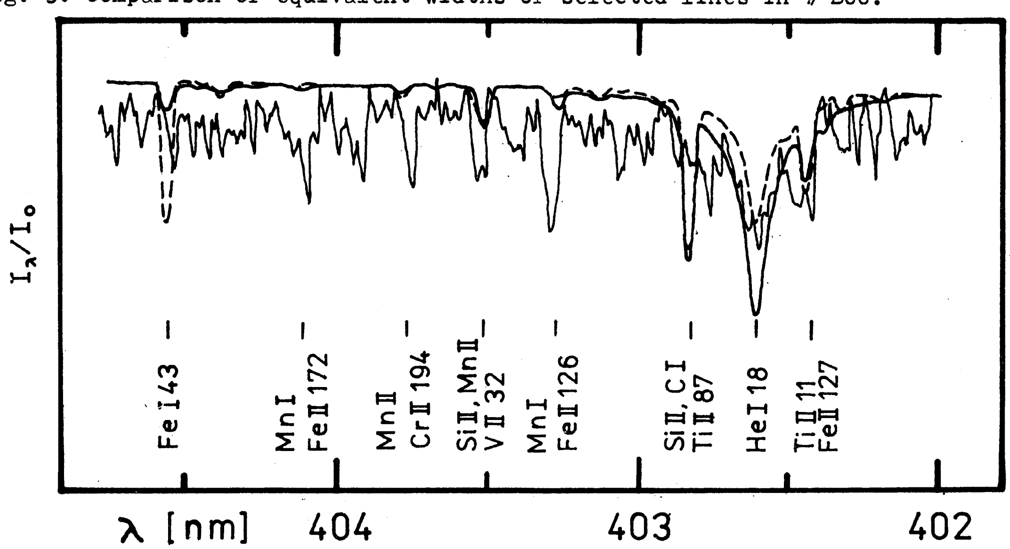

Fig. 4. Comparison of a part of the synthetic and observed spectra.

Tab. I

λ	Line	W_λ		λ	Line	W_λ	
375.8235	Fe I 21	-		393.0952	Mn II	┘10.0	
.9287	Ti II 13 ┐			.1990	Ti II 34	-	
.9456	Fe II 154 ┘	9.7		.3663	Ca II K	25.7	
376.1323	Ti II 13	5.7		394.1277	Mn II	5.4	
.1875	Ti II 107	5.3		.3860	Mn II	12.2	
.2893	Fe II 192	6.2		395.0360	Y II 6	6.7	
.3789	Fe I 21	15.6	?	396.8468	Ca II H	14.9	
378.8700	Y II 7	12.3		398.2583	Mn I 33 ┐		?
.9482	Cr I 41	7.2	?	.2600	Y II 6 ┘	10.4	
381.2283	Mn II ┐			.3994	Hg II	19.9	
.2524	Mn II ┘	18.1		400.0033	Mn II	5.6	
384.4206	Mn II	18.3		402.4548	Fe II 127 ┐		
.5173	Fe II 127	-		.5137	Ti II 11 ┘	16.3	
385.3157	Cr II	4.1		.6199	He I 18	25.5	
.3660	Si II 1	9.6		.8328	Ti II 87	-	
.6020	Si II 1	13.7		.8457	Si II	-	
386.2600	Si II 1	13.5		403.2935	Fe II 126 ┐		
.3938	Fe II 127	-		.3062	Mn I 2 ┘	9.6	?
.5525	Fe I 20	6.2		.5271	Si II ┐		
.6531	Cr II 130	-		.5623	V II 36 ┘	8.4	
387.2766	Fe II 29	-		.8013	Cr II 194	6.0	
.8572	Fe I 4	4.1		404.1355	Mn I 5 ┐		
.9041	Mn II	7.8		.1636	Fe II 172 ┘	5.4	
389.8109	Mn II	21.0		.8821	Fe II 172	-	
390.0518	Ti II 34	8.0		405.1946	Cr II 19	4.7	
.5470	Mn II ┐			.3801	Ti II 87		
.5522	Si I 3 │	14.4		.4097	Cr II 19	5.3	
.5645	Cr II 167 ┘			406.3594	Fe I 43	-	
.6038	Fe II 173	4.6		.7029	Ni II 11	3.5	
391.3447	Ti II 34	10.6		407.6616	Fe I 558 ┐	-	
.4329	V II 33	-	?	.6780	Si II ┘	-	
.7318	Mn II	10.7		.7709	Sr II 1 ┐		
.8638	Fe I 430	-		.7810	Hg I ┘	8.9	
.9067	Fe I 430	-		408.1490	Mn II	8.7	
392.0662	Fe II ┐			.3628	Mn I	-	?
.0680	C II 4 ┘	10.8		.6150	Cr II 26	7.5	
.2004	Fe II	10.7		412.0798	He I 16	6.8	
.6528	He I 58	12.2		.2651	Fe II 28	-	
.7920	Fe I 4	-		.4787	Fe II 22		
393.0298	Fe I 4	6.0		.4920	Y II 14	9.5	
.0660	Y II	┐10.0		.8052	Si II 3	19.4	

Table I continued

412.8728	Fe	II	27	-	
413.0872	Si	II	3	] 16.6	
.0894	Si	II	3	]	
.6959	Mn	II		16.4	
414.3870	Fe	I	43	10.1	
.5772	Cr	II	162	-	
417.1560	Mn	II		] 12.1	?
.2060	Ga	I	1	]	?
.3446	Fe	II	27	5.6	
.4339	Mn	II	2	8.4	
.7540	Y	II	14	10.7	
.8465	P	II		] 9.7	?
.8848	Fe	II	28	]	
418.4315	Ti	II	21	6.8	
419.5318	Fe	I	693	-	
.9098	Fe	I	522	-	
420.0328	Mn	II		9.3	
.0657	Si	II		] 4.0	
.0897	Si	II		]	
.2032	Fe	I	42	-	
.4700	Y	II	1	4.9	
.5401	Mn	II	2	9.9	
.6354	Mn	II	7	17.9	
421.5519	Sr	II	1	10.8	
423.3159	Fe	II	27	12.5	
.3245	Cr	II	31	-	
.3612	Fe	I	152	-	
.5730	Y	II		-	
.5942	Fe	I	152	-	
.7866	Mn	II		6.8	
.8798	Fe	I	693	] 17.3	
.8811	Mn	II	2	]	
424.0442	Mn	II		8.7	
.2355	Cr	II	31	] 11.2	
.2389	Mn	II		]	
.2920	Mn	II		6.8	
.4240	Mn	II	7	8.1	
.6829	Sc	II	7	6.9	
.7415	Fe	I	693	3.0	
.7950	Mn	II		10.5	
425.0125	Fe	I	152	-	
.0789	Fe	I	42	] 6.8	
.1150	Ga	II		]	
.1775	Mn	II		7.3	

425.3016	Mn	II	7	19.1	
.4040	Ga	II		] 5.8	
.4331	Cr	I	1	]	
.5720	Ga	II		] 14.6	
.5780	Ce	II	81	]	?
.8144	Fe	II	28	-	
.9191	Mn	II	7	9.2	
426.0479	Fe	I	152	-	
.1924	Cr	II	31	] 15.8	
.2090	Ga	II		]	
.7030	Mn	II		] 11.1	
.7261	C	II	6	]	
427.1638	Fe	I	152	-	
.1763	Fe	I	42	-	
.3315	Fe	II	27	5.5	
.4796	Cr	I	1	] 5.0	
.5571	Cr	II	31	]	
.8149	Fe	II	32	9.6	
428.1984	Mn	II		] 17.7	
.2177	Mn	II		]	
.2405	Fe	I	71	]	
.3751	Mn	II	6	4.8	
.4208	Cr	II	31	] 8.3	
.4427	Mn	II	6	]	
.7872	Ti	II	20	3.6	
.9714	Cr	I	1	3.3	
429.0237	Ti	II	41	5.2	
.2246	Mn	II	6	12.4	
.4098	Ti	II	20	6.5	
.4127	Fe	I	41	-	
.4766	Sc	II	15	-	
.6563	Fe	II	28	4.4	
.9246	Fe	I	152	1.0	
430.0056	Ti	II	41	13.5	
.1938	Ti	II	41	-	
.3166	Fe	II	27	9.1	
.5443	Sr	II	3	2.5	
.5707	Sc	II	15	-	
.7879	Ti	II	41	] 10.1	
.7905	Fe	I	42	]	
.9630	Y	II	5	6.3	
431.2871	Ti	II	41	2.1	
.4081	Sc	II	15	7.6	
.4960	Ti	II	41	3.6	

Table I continued

432.0719	Sc	II	15	4.2	
.4990	Sc	II	15	8.8	
.6643	Mn	II		12.2	
434.3968	Mn	II	6	10.5	
.5591	Mn	II	6	6.1	
.8518	Sc	I		8.8	?
435.1762	Fe	II	27	7.9	
.6678	Mn	II		4.8	
.8350	Hg	I		6.2	
.8730	Y	II	5		
439.4837	Cr	I	130	8.5	
.5036	Ti	II	19		
.8020	Y	II	5	9.8	
440.4753	Fe	I	41	7.0	
442.2590	Y	II	5	-	
443.3980	Mg	II	9	9.6	
.4067	Mn	II			
446.8485	Ti	II	31	4.2	
447.0869	Ti	II	40	-	
.1500	He	I	14	2.7	
.2622	Fe	II	37	-	
.8709	Mn	II		9.7	
448.1136	Mg	II	4	29.9	
450.1262	Ti	II	31	-	
.3136	V	II	13	8.5	
.8280	Fe	II	38	13.1	
451.0511	Fe	II		5.0	
.5331	Fe	II	37	12.5	
.9224	Mn	II		16.1	
.9242	Mn	II			
452.0217	Fe	II	37	7.5	
.2624	Fe	II	38	-	
.4691	Ti	II	60	10.4	
453.3962	Ti	II	50		
.4162	Fe	II	37	9.8	
.4294	Mg	II	26		
454.1515	Fe	II	38	4.3	
.9193	Fe	II	186	14.8	
.9464	Fe	II	38		
.9622	Ti	II	82		
455.4982	Cr	II	44	10.8	
.5883	Fe	II	37	11.3	
.8642	Cr	II	144	11.8	
456.3764	Ti	II	50	-	
457.1951	Ti	II	82	8.4	
.6334	Fe	II	38	5.2	
458.2829	Fe	II	37	7.3	
.3831	Fe	II	26	9.4	
.8203	Cr	II	44	14.0	
459.2049	Cr	II	44	21.0	
461.6120	Cr	I	21	13.2	?
.6625	Cr	II	44		
.8794	Cr	II	44	12.0	
462.9321	Ti	I	145	9.3	
.9336	Fe	II	37		
463.3980	Zr	I	5	11.9	?
.4092	Cr	II	44		
.5327	Fe	II	186	5.9	
467.8832	Fe	I	821	12.3	
468.8352	Ti	I	306	6.8	
.9379	Cr	I	186	4.6	
470.2583	Fe	II		6.6	
472.7854	Mn	II	5	14.6	
473.4141	Sc	I	14	9.8	
.7659	Sc	I	14	25.2	
.8011	Mn	II	5		
475.5723	Mn	II	5	17.6	
476.2367	Mn	I	21	-	
.4732	Mn	II	5	13.2	
478.3427	Mn	I	16	-	?
.4320	Sr	I	5	-	?
480.6162	Mn	I			
.6326	Ti	II	17	15.2	
.6894	Mn	II			
482.3310	Y	II	22		
.3524	Mn	I	16	21.8	
.4080	Cr	II	30		
.9372	Cr	I	31		
.9498	Ni	II		16.3	?
483.0138	Mn	II			
487.6320	Sr	I	5		?
.6370	Cr	II	30	10.6	
.6456	Cr	II	30		
488.3600	Zr	I	44		?
.3690	Y	II	22	14.3	
489.1499	Fe	I	318	-	
492.0523	Mn	II		-	?
.3897	Fe	II	42	18.5	

The following values were derived for the stellar parameters:

$M_{bol} = -1.12 \pm 0.3$ $L_*/L_\odot = 223 \pm 49$,

$M_*/M_\odot = 3.8 \pm 0.5$ $R_*/R_\odot = 2.8 \pm 0.4$,

v sin i (Mg) = 19 ± 5 km s^{-1}, Sp = B7V.

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