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Research Note

Helium peculiar stars in the red spectral region*

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Abstract. Based upon 33 A/mm dispersion spectroscopic material we examine if equivalent widths of H and He lines can be used for the detection of new helium-peculiar stars. The answer is affirmative and we present some new candidates discovered this way.

We have also investigated if the use of different helium lines than those of the ^{3}D series (4026, 4471) modifies the assignments of helium peculiar stars. This is not the case, since the use of λ 6678 (^{1}D) and λ 7065 (3S) gives the same results.

Key words: stars: chemically peculiar – stars: early-type

1. Introduction

Helium peculiar stars are a well known group of early B-type peculiar stars. They are usually subdivided into intermediate helium stars and extreme helium stars. In the first group the relative strength of helium to hydrogen lines is changed, being either smaller or larger than in normal stars. In a certain number of objects the strength of the helium lines changes over a cycle of a few days. In extreme helium stars the amount of hydrogen is very small or zero compared to that of helium.

Helium-peculiar stars have been recognized through spectral classification or by combining photometry with spectral classification. In spectral classification procedures the classifier compares the strength of the hydrogen and helium lines with those of the standard stars and with some practice one can detect rather easily helium abnormal objects (see for instance Garrison 1967). What is needed however in all methods is to obtain the spectra of a large number of objects, since the proportion of helium abnormal objects is of the order of a few percent of all B-type stars.

In the photometric-spectroscopic procedures one preselects candidates for helium anomaly through the comparison of photometric indices which provide the spectral type (for instance by means of the Q method in UBV photometry; see Johnson and Morgan 1953) with the spectral classification. Since helium lines are used as a classification criterion, helium weak or strong stars show up as differences between the photometric and the spectroscopic classification (see for instance Jaschek et al. 1969).

A purely photometric approach has also been undertaken by Danish astronomers. (See for instance Nissen 1974). They measured with interference filters a hydrogen line and a helium line and can single out easily the helium abnormal objects. The method is quick, but works well only for stars in which helium lines are strong because the interference filter cannot measure precisely very weak lines.

The present work intends to do the same, but by using equivalent width measures of hydrogen and helium lines. The idea was to observe a certain number of known stars to make sure that the method works properly and then to make a survey to find more helium abnormal stars. The survey has not been done because of the lack of observing time. We shall present here the results obtained so far.

2. Observational material

All observations were made at the Haute Provence Observatory of the CNRS (OHP), at the 193 cm telescope, with the Carelec spectrograph (Lemaitre et al. 1990) and at the 152 cm telescope with the Aurélie spectrograph (Gillet et al., 1994).

The Carelec spectrograph has a grating blazed at 7500 Å. From 1990 to 1993 a CCD Thompson detector was used, with 512×384 pixels of 23 μ, resolution about 1 A and a dispersion of 33 Å/mm. From 1993 on a TK 512 detector was used, with 512×512 pixels of 27 μ, resolution 1.2 Å, dispersion 33 Å/mm. The calibration in wavelength range was made with a Ne and Ar lamp, whereas the correction for flat field was made with a tungsten lamp mounted in the spectrograph.

The Aurélie spectrograph uses a grating with 300 lines, blazed at 6000 Å. The detector was a double barrette TH 7832 with 2048 photodiodes of 13 μ, giving a resolution of 1.3 Å and a dispersion of 33 Å/mm.

The flat field correction was made with a tungsten lamp mounted in the spectrograph and the calibration in wavelength with a hollow cathode of Th and Ar.

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* Based on observations obtained at the Haute Provence Observatory (CNRS)

Table 1. Observational data

HD	Date	Reg	HR or position			
21699	18.02.92	70	1063			
22920	19.02.02	70	1121			
23408	18.02.92	70	1149			
28446	23.02.92	H3	1417			
30836	23.02.92	H3	1552			
34078	23.02.92	H3	1712			
34503	23.02.92	H3	1735			
34656	19.02.92	70		5.17.3	+37.23	6.79
36371	23.02.92	H3	1843			
36678	19.02.92	70	1866			
	23.02.92	H3				
36916	19.02.92	70		5.32.4	–04.09	6.78
36958	19.02.92	70		5.32.6	–04.46	7.35
37017	19.02.92	70		5.32.9	–04.32	6.51
37058	19.02.92	70		4.33.1	–04.52	7.34
37129	19.02.92	70		4.33.6	–04.09	7.14
37321	19.02.92	70		5.35.0	–01.23	7.09
37479	23.02.92	H3	1932			
37742	18.02.92	70	1948			
37776	19.02.92	70		5.36.4	–01.32	6.98
46150	23.02.92	H3		6.29.3	+04.50	6.73
47432	18.02.92	70	2442			
49606	19.02.92	70	2519			
	23.02.92	H3				
51688	19.02.92	70	2605			
	23.02.92	H3				
79158	18.02.92	70	3652			
	23.02.92	H3				
87901	14.4.96	H3,70	3982			
90994	14.04.96	H3,70	4119			
100340	18.02.92	70		11.30.3	+05.33	10.19
120315	18.04.92	H3	5191			
135485	18.02.92	70		15.13.0	–14.30	8.20
144470	13.04.96	H3,70	5993			
148112	19.06.95	H3	6117			
149757	13.04.96	H3,70	6175			
164353	19.06.95	H3	6714			
	21.06.95	70				
167838	20.06.95	H3		18.14.6	–15.27	6.73
176437	19.06.95	H3	7178			
	20.06.95	H3				
	21.06.96	70				
176582	19.06.95	H3	7185			
177003	19.06.95	H3	7210			
180553	19.06.95	H3	7305			
181828	19.06.95	H3	7346			
182568	10.06.95	H3	7372			
183143	20.06.95	H3		18.25.2	+18.12	6.84
	21.06.95	70				
184927	19.06.95	H3		19.33.6	+31.10	7.46
184930	20.06.95	H3	7447			
	21.06.95	70				
186122	10.06.95	H3	7493			
186205	19.06.96	H3		19.40.1	+09.06	8.53
190919	21.06.95	70		20.00.4	+35.31	7.54
191746	19.06..95	H3		20.08.5	+28.17	7.17
191263	19.06.95	H3	7700			
198183	19.06.95	H3	7963			
198513	19.06.95	H3	7978			
200595	19.06.95	H3	8064			
201834	19.06.95	H3	8106			
206183	20.05.95	H3		21.36.9	+56.45	7.55
214923	20.06.95	H3	8634			
214993	20.06.95	H3	8640			

Column explanation:
HD-HD number
Date-Date (Day,month,year-1900)
Reg:- H3: H3 region 70: 7000 region
HR or position-HR number or 1950 position plus V

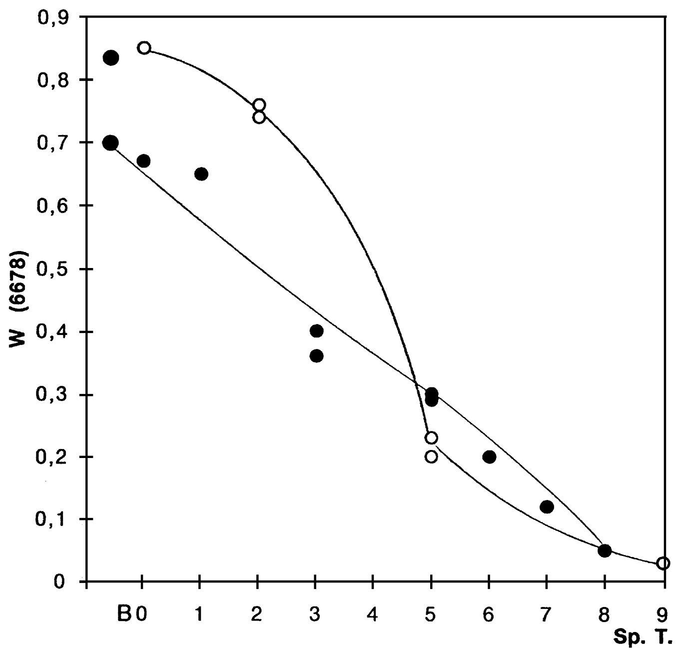

Fig. 1. Equivalent width of He I (6678) as a function of spectral type and luminosity class. Empty circles: class III, filled circles: class V

We have measured the H α(=H3) line, λ 6678 and some Si II lines (ll 6347, 6372) if they were strong. In the other spectral region we have measured only the equivalent width of the λ 7065 line. The observational data for all stars are given in Table 1. Tables 2 and 3 provide the observed equivalent widths for all stars of the program, and in Tables 4, 5 and 6 these are given for the MK standards which have been measured. MK standards had been observed already earlier (Jaschek et al. 1994). The plots of the equivalent widths versus spectral types of the standards are given in Figs. 1, 2 and 3, where the previously published values have been included.

The behavior of the λ 6347 Si II line is as follows: $B2 = 0.10$, $B5 = 0.25$, $B8 = 0.22$, $A0 = 0.16$ for both class V and class III stars. The luminosity effect for supergiants is positive and very pronounced.

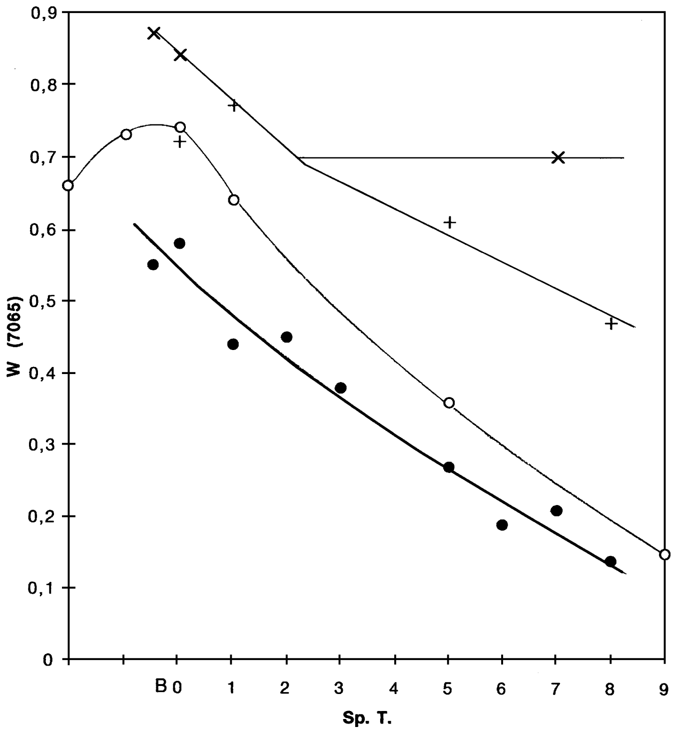

Fig. 2. Equivalent width of He I (7065) as a function of spectral type and luminosity class. X: class Ia +: class Ib empty circles: class III, filled circles: class V

With regard to errors in the equivalent widths, repeated measures of the same line and comparison of measures carried out on different nights lead to the conclusion that strong lines have errors of the order of ±10% and weaker lines somewhat more.

3. Results

We use the equivalent width of the Hα line for the temperature classification and that of the helium lines to assess the degree of normality or abnormality of helium. We plot in Fig. 4 the relation between the equivalent widths of Hα and λ 6678 lines. As can be seen, the scatter is relatively small for the normal stars, except for the $B5V$ standard (HD 198183) and two others. There is some separation of He weak stars, lying below the line for normal stars, and He strong stars lying above the line.

We have checked the results obtained with the Q method of the UBV photometry. In general one knows that UBV photometry yields reasonably good equivalents of spectral types, which can replace H alpha equivalent widths. We then compared the spectral type so obtained with the spectral type derived from the helium lines. The corresponding data are given in Tables 7 and 8.

From Table 2 and Table 7, we can conclude that very satisfactory agreement exists between the assignment of the He stars to the two categories of helium weak or helium strong stars, with only two conflicting cases, HD 182568 and HD 200595. The first case is marginal for the Q method, since the discrepancy between the spectral type derived from the Q method and the He line type differs by only one tenth. The star HD 200595 presents

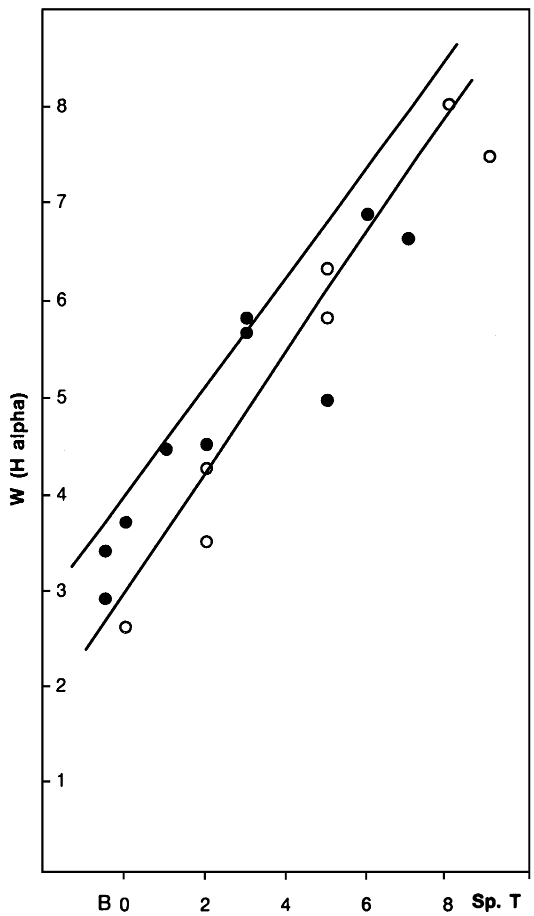

Fig. 3. The equivalent width of H(α) as a function of spectral type and luminosity class. Empty circles: class III, filled circles, class V

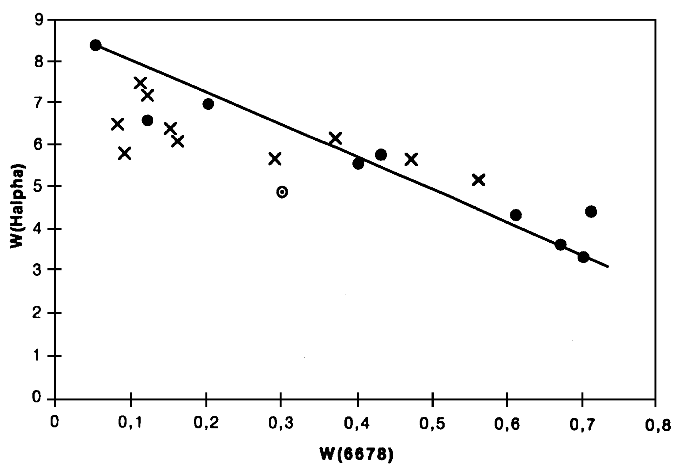

Fig. 4. Plot of the equivalent widths of He I 6678 vs. H(α). Dots: standard stars, crosses: helium-peculiar stars. Circle with dot is HD 198199

also a marginal case: in the Q method the star is marginally strong, whereas it is normal in the direct assignment.

The treatment of the measures of λ 7065 unfortunately can not be done along the same lines as that of λ 6678, since because of the restrictions of observing time not all stars for which

Table 2. Data and equivalent widths of λ 6678

HD	Hα	6678	From Q	From graph
36678 [b]	7.83	00	w	w
37479	3.07	1.11	ss	s
49606 [b]	5.86	0.09	w	w
51688 [b]	6.46	0.08	w	w
79158 [b]	6.11	0.16	w marg	w
176582	5.67	0.28	w	w
177003	5.79	0.07	w marg	w
180553	6.36	0.15	w	w
181828	7.24	0.12	w	w
182568	5.24	0.56	w marg	n, Conflicting
184927	4.91	0.94	ss	s
186122	9.67	0.0	w	n
186205	5.30	1.24	s	s
198513[a]	8.14	0.13	w	n
200595	8.24	0.37	s marg	n, Conflicting
201834	7.45	0.11	w	w

[a] Si II strong
Abbreviations: n=normal s=strong ss=very strong w=weak marg=marginal
[b] observed in both λ 6678 and 7065
The term "Conflicting" stands for discrepancies between the Q classification and the evidence from λ 6678 (see text). b) Other objects also observed.
Subdwarfs
HD 100340 (11.30.3 +05.33 V=10.19) classified as helium strong, but in reality it is an O-type subdwarf with He II lines.
BD +13° 3224 (16.45.8 +13.21 V=10.53) we have two spectra, taken at one day interval and both H 3 and He I are variable. Some additional lines also show changes.

λ 7065 was measured could also be measured in Hα. For these measures we have thus adopted the Q method mentioned before.

4. Discussion

One of the points we had in mind was to see if the use of helium lines belonging to different series made any difference. The line which had been used for photometry was λ 4026 which belongs to the ^{3}D series, whereas we work with λ 6678 (^{1}D series) and with λ 7065, (^{3}S series). It is a well known fact that in some kinds of He abnormal stars the different series do not show a similar behavior, so that a test would be most welcome. As can be seen from a comparison of the assignments made by us on the basis of specific lines (different from λ 4026), they agree with the assignments made in the literature. We find thus no effect related to the lines of the different series used. A direct comparison is possible in the four stars which were observed in both $\lambda\lambda$ 6678 and 7065, and as expected, the four cases agree in the assignment.

A second point we can examine is the degree of agreement between the spectral types as given in the literature with the spectral types derived from the He line. We exclude from this comparison the helium variables, for obvious reasons. For the re-

Table 3. Data and equivalent widths of λ 7065

HD	7065	Group	JE
21699	–	weak	v
22920	–	weak	w
23408	–	weak	w
34503[a]	–	weak	·
36668	–	weak	w
36916	–	w	w
36958	0.28	weak	w
37017	0.45	normal	v
37058	0.36	weak	v
37129	0.39	normal	w
37321	0.19	weak	v
37776	0.59	w	v
49606	0.03	weak	w
51688	–	weak	w
79158	–	weak	w
135485	0.45	strong	s

Abbreviations as in Table 1. JE stands for assignment in the catalogue of Jaschek and Egret(1982): s=strong w=weak v=variable
[a] MK standard
Column explanation:
First column: HD number
Second: equivalent width of λ 7065, in A.
Third: Helium group assignment
Fourth: Helium group assignment in the catalogue of Jaschek-Egret (1982)

Table 4. Equivalent widths of H α in MK standards

HD 28446	B0 III	2.61	34078	0 9.5 V	3.45
			149757	0 9.5 V	2.95
30836	B 2 III	3.49	206183	B 0 V	3.69
			144470	B 1 V	4.48
	B 2 III	4.26	191746	B 2 V	4.53
184930	B 5 III	6.34	191263	B 3 V	5.83
34503	B 5 III	5.79	120315	B 3 V	5.65
	B 8 III	8.0	198183	B 5 V	4.96
			90994	B 6 V	6.85
			87901	B 7 V	6.64
176437	B 9 III	7.45	214923	B 8 V	8.43

Table 5. Additional MK standards observed for λ 7065

HD 183143	B 7 Ia	0.70	184930	B 5 III	0.32
47432	O 9.7 Ib	0.84	176437	B 9 III	0.14
37742	O 9.7 Ib	0.73	149757	O 9.5 V	1.11
190919	B 1 Ib	0.77	144470	B 1 V	0.66
164353	B 5 Ib	0.61	90994	B 6 V	0.19
34656	O 7 III	0.82	87901	B 7 V	

Column explanation:
First: HD number
Second: Spectral classification
Third: Equivalent width of the line, in Å.

Table 6. Additional standards observed for λ 6678

HD 167838	B 5 Ia	0.92	206183	B 0 V	0.67
183143	B 7 Ia	0.60	144470	B 1 V	0.61
164353	B 5 Ib	0.76	191746	B 2 V	0.71
30371	B 5 Ib	0.97	191263	B 3 V	0.45
	B 2 III	0.76	198183	B 5 V	0.29
184930	B 5 III	0.24	90994	B 6 V	0.20
149757	O 9.5 V	0.85	87001	B 7 V	0.11
46150	O 9 V	0.44	214983	B 8 V	0.05

Column explanation:
First: HD number
Second: spectral classification
Third: equivalent width of the line, in Å.

Table 7. Data and equivalent widths of λ 6678

HD	$B-V$	$U-B$	From Q	Sp.type	From 6678	Ass	JE	
36678[b]	–.11	–.45	B 6	B 9 IIIp	B 9	w		w
37479	–.19	–.86	B 2	B 2 Vp	very str	s		v
49606[b]	–.13	–.52	B 5.5	B 7 IIIp	B 7	w		w
51688[b]			(B 5)	B 8 IVp	B 7	w		w
79158[b]	–.14	–.50	B 6	B 9 III	B 7	w	marg	w
176582	–.17	–.71	B3	B 5 IV	B 5	w		v
177003	–.19	–.76	B 2	B 2.5 IV	B 8	w	marg	v
180553	–.06	–.59	B 3	B 5 V	B 7.5	w		–
181828	–.12	–.51	B 5	B 9 V	B 8	w		–
182568	–.09	–.72	B2	B 3 IV	B 1	w	marg.	v
184927	–.17	–.82	(B 3)	B 2 V	very str	s		v
186122	–.03	–.41	B 6	B 9 III	>B 9	w		–
186205	+.05		(B 4.5)		very str	s		s
198513[a]	–.07	–.56	B 4	B 8NP	B 7.5	w		–
200595	–.15	–.55	B 5	B 3 Vn	B 3	s	marg	–
201834	–.12	–.45	B 6	B 9 III	B 8	w		–

Notes: [a] Si II strong Values between parentheses are from Hα eq. width
[b] observed in both λ 6678 and 7065
Ass=group assignment JE=group assignment in the catalogue of Jaschek and Egret (1982): s=strong w=weak v=variable

mainder we find close agreement (within one tenth of a spectral type) in nine cases and disagreements in two cases. In HD 79158 the disagreement is of $B9$ III to $B7$ and in HD 189553, $B5\ V$ to $B7,5$. If we assume that the precision of spectral classification is about ±1 tenth, we expect to find 3 disagreements in ten cases and that is about what we find. The comparison between the types is thus consistent with the precision of spectral classification.

A third point we want to emphasize is that the method works well and quickly. If only measurements of Hα and λ 6678 are considered, one exposure of 8 minutes suffices for a sixth magnitude star. The fact that several Si II lines are present in the same region also guarantees that no Si stars are unduly included in the sample.

Table 8. Data and equivalent widths of λ 7065

HD	$B-V$	$U-B$	Spt(C)	Spt	7065	Group	JE
21699	+.10	–.57	B 2	B 8 III p	B 9.5	weak	v
22920	–.15	–.57	B 5	B 9 IIIp	B 9.5	weak	w
23408	–.07	–.40	B 5.5	B 8 III	B 9.5	weak	w
34503[a]	–.11	–.47	B 6	B 5 III	B 8	weak	·
36668	–.11	–.45	B 6	B 6 V p	B 9.5	weak	w
36916	+.30	+.03	B2	B 8 IIIp	B 9.5	w	w
36958	–.08	–0.59	B 3	B 2 IV	B 5	weak	w
37017	–.14	–.77	B 2	B1.5 Vp	B 2	normal	v
37058	–.12	–.58	B 2	B 2 V	B 3.5	weak	v
37129	–.15	–.70	B 3	B 2.5 V	B 3	normal	w
37321	–.08	–.55	B 5	B 5 V	B 7	weak	v
37776	–.14	–.86	B 1	B 1.5 V	B 0	w	v
49606	–.13	–.52	B 5.5	B 7 IIIp	B 9.5	weak	w
51688			(B 6)	B 8 IVp	B 9.5	weak	w
79158	–.14	–.50	B 6	B 9 III	B 9.5	weak	w
135485	–.08	–.54	B 5	B 5 IIp	B 2	strong	s

[a] Standard MK
Sp(C) is the spectral type derived from the UBV colors.

We have found with the method three new candidates for helium stars: HD 198513, 200595(marginal), 201834 (see Table 7). As far as the standards stars HD 198183 (Table 7) and 34503 (see Table 8) are concerned, we propose to put the two objects in the category of "peculiar in the red". We have recently created a similar category of standards "peculiar in the infrared" (Jaschek & Andrillat 1998) which behave quite normally in the blue region but present some anomalies of equivalent widths in the infrared region and the two abovementioned stars represent similar cases.

We hope to use this method in a future survey of B stars.

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