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PHOTOELECTRIC MEASURES OF HYDROGEN LINES IN HELIUM-WEAK STARS

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RESUMEN

Se presentan las mediciones fotométricas de las líneas de Balmer, Hα, Hβ y Hγ en estrellas de helio débil y también en algunas estrellas empleadas como standards. De 12 estrellas de helio débil observadas, se encuentra que 9 de ellas se ubican en el diagrama (α, β) indicando un espectro más temprano que su clasificación MK. Las 3 estrellas restantes no sugieren diferencia con su tipo espectral MK. Resultados similares se obtienen de la fotometría UBVRI.

ABSTRACT

Photoelectric measures of the Balmer lines Hα, Hβ and Hγ in helium-weak stars and also in some stars employed as standards are presented. From 12 helium-weak stars which were measured, 9 are located in the (α, β) array indicating earlier spectral type than their MK classification. The other 3 stars suggest no difference with their classified MK spectral type. Similar results are derived from their UBVRI photometry.

Key Words: **HELIUM-WEAK STARS — PHOTOMETRY — BALMER LINES.**

I. INTRODUCTION

In a previous paper (Feinstein 1974; hereafter Paper I) a system of photoelectric photometry of the Balmer lines Hα, Hβ and Hγ was defined. Several types of stars were measured in this system, especially those displaying emission in the hydrogen lines. For the β index, the standard stars listed by Crawford and Mander (1966) and Crawford, Barnes and Golson (1970) were employed. But for the α and γ indices the reductions were derived by means of the same stars employed in Paper I. A photometric system for the Hα line using slightly difference interference filters was reported recently by Dachs and Schmidt-Kaler (1975) and by Baliunas, Ciccone and Guiman (1975).

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More data obtained in the Balmer lines and also in the UBVRI system are presented here with special emphasis on the helium-weak stars described by Jaschek and Jaschek (1974).

II. THE OBSERVATIONS

New photoelectric measures were carried out during November and December 1974 with the 1-m and the 90-cm telescopes of the Cerro Tololo Inter-American Observatory. During the observing run a 1P21 photomultiplier with standard interference filters for the Balmer lines was employed. Those for the Hα line, Nos. 210 and 71 of the KPNO, are the same which were used to define the system. Standard stars from Table 2 of Paper I were employed to reduce the instrumental system into the standard system.

Standard, Be and helium-weak stars are measured, but only data of the standard and helium-weak stars

TABLE 1

PHOTOELECTRIC PHOTOMETRY OF THE BALMER LINES IN STANDARD STARS

HD	α	β	γ	n	Sp. Type
15318	1.511	2.832	2.338	1	B9.5 III
17081	1.498	2.690	2.207	8	B7 V
23754	1.493	2.670	2.140	8	F3 III
24587	1.483	2.705	2.218	8	B6 V
30652	1.491	2.669	2.125	7	F6 V
30836	1.477	2.602	2.107	18 N	B2 III
33904	1.492	2.719	2.226	14 N	B9p Mn-Hg
34816	1.473	2.600	2.102	15 N	B0.5 IV
36591	1.475	2.622	2.114	13 N	B1 IV
44743	1.479	2.590	2.090	11 N	B1 II-III
53244	1.491	2.681	2.179	15 N	B8 II
65810	1.509	2.837	2.331	15 N	A2 V
71155	1.516	2.881	2.377	18 N	A0 V
73262	1.513	2.853	2.337	13 N	A1 V
74280	1.484	2.646	2.148	19 N	B4 V
214923	1.495	2.750	2.256	3	B8 V
222368	1.482	2.660	2.106	9 N	F8 V

will be presented here, as the problem of the Be stars will be discussed elsewhere.

Table 1 contains for the standard stars, the HD number, the α, β and γ indices, and the number of measures. If new measures are included besides those of Table 2 of Paper I, a N follows it. The last column lists the spectral type according to the Catalogue of Kennedy (1975).

TABLE 2

PHOTOELECTRIC PHOTOMETRY OF THE BALMER LINES IN HELIUM-WEAK STARS

HR Name	HD	α	β	γ	n	Sp. Type	Ref.
α Scl	5737	1.483	2.665	2.147	4	B8 III	1
939	19400	1.496	2.747	2.208	4 N	B9 IV	2
1063	21699	1.527	2.683	2.192	1	B8 III	1
1100	22470	1.473	2.696	2.218	5 N	B9 V	2
1121	22920	1.487	2.666	2.181	5 N	B9 V	2
20 Tau	23408	1.482	2.676	2.166	2	B7 III	1
1441	28843	1.480	2.687	2.201	5 N	B9 III	2
2509	49333	1.509	2.680	2.179	5 N	B9 IV	2
3448	74196	1.474	2.702	2.207	1	B8 IV	2
36 Lyn	79158	1.472	2.697	2.195	2	A1	1
5378	125823	1.471	2.658	2.160	8	B3 V	1
8137	202671	1.489	2.764	2.174	2	B8 p	2

1) Catalogue of bright stars.
2) Jaschek *et al.* (1969), and Jaschek (private communication).

In Figure 1 is displayed the (α, β) array for all the stars listed in Table 1, including the standard sequence from 09 to B9 given by Feinstein (1976). The spectral types on the right margin were based on the calibration presented by Crawford (1975). The number in each point gives the spectral type of the B-type stars. Some stars later than A0 are also plotted.

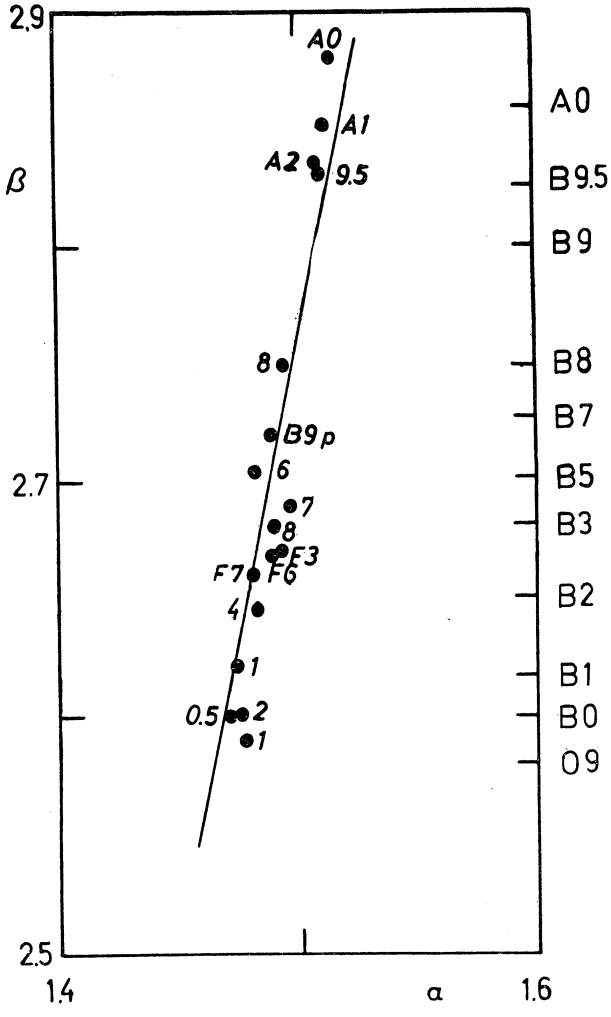

FIG. 1. (α, β) array for the standard stars of Table 1. The line indicated the standard sequence from Feinstein (1976). At the right margin is given the calibration of the spectral types with β index taken from Crawford (1975). The number near each dot means the spectral type for the B stars. Later spectra are given with their letters.

III. HELIUM-WEAK STARS

The 12 helium-weak stars observed photoelectrically in the Balmer lines are listed in Table 2. It contains for each star the HR number or its name, the HD number, the observed α, β and γ indices and the number of measures. The letter N which follows, refers that the mean values include new measures added to the previous data of Table 4 (Paper I). The last column lists the spectral types obtained from Jaschek, Jaschek and Arnal (1969).

The (α, β) array for the helium-weak stars is shown in Figure 2. The full line is the same standard

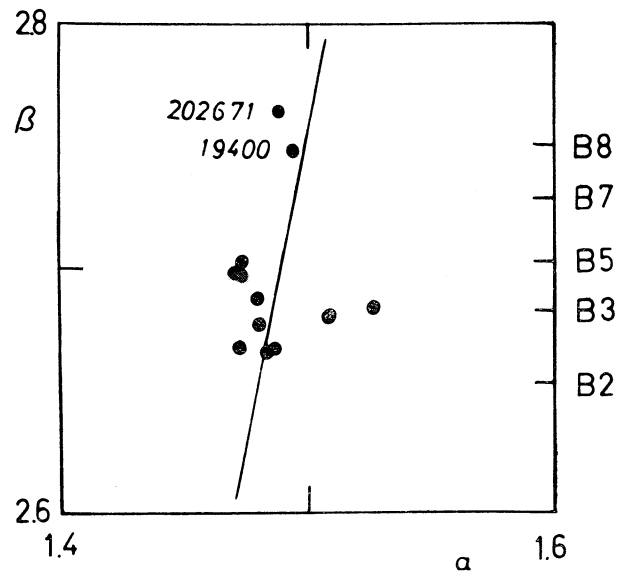

FIG. 2. (α, β) array for the helium-weak stars of Table 2, with the standard sequence from Feinstein (1976).

sequence for normal stars as explained above. The two stars, HD 19400 and HD 202671, are both located in the position of the B8-type in agreement with their assigned MK spectral types. But for the other 10 stars, α and β indices suggest spectra about B2 – B5, and with one exception, HD 125823, the remaining are in disagreement with the spectral classification derived for these stars.

The star HD 125823 was classified by Jaschek and Jaschek (1967) as B3V, but with the helium lines intensities corresponding to spectral type B8. Later, it was described as a spectrum variable star by

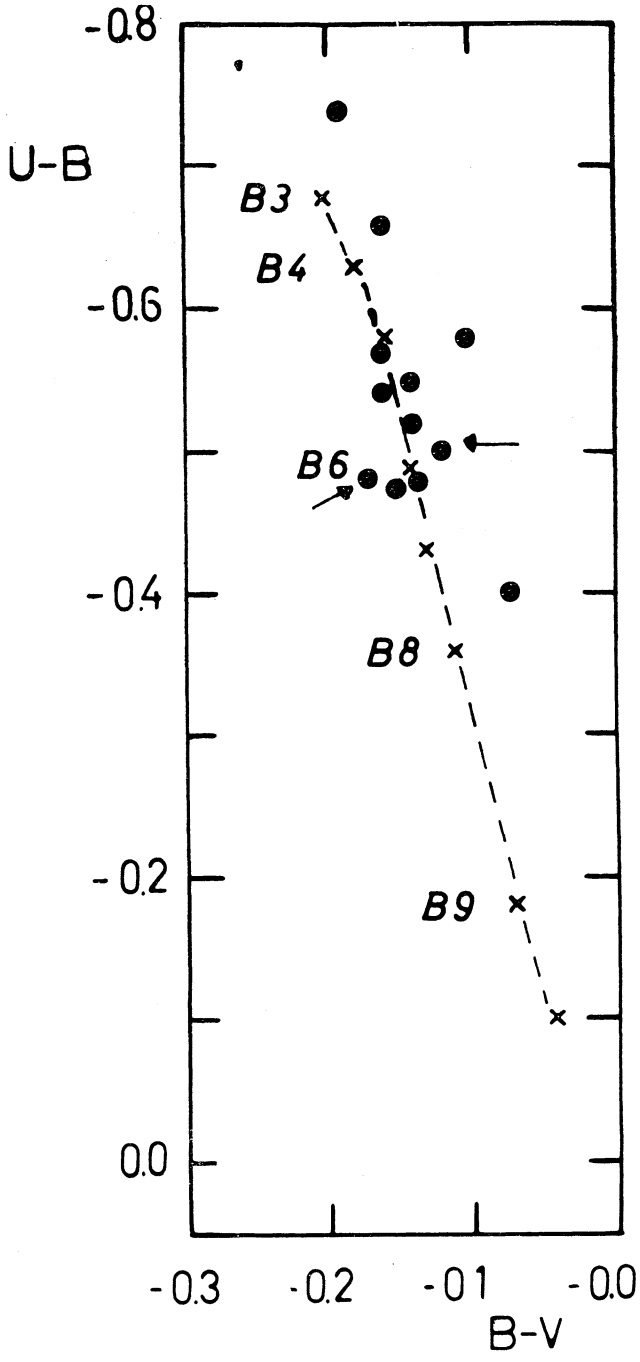

FIG. 3. (B-V, U-B) array for the helium-weak stars, with the intrinsic color relation taken from FitzGerald (1970). The two arrows point out the stars HD 19400 and HD 202671.

Jaschek, Jaschek and Kucewicz (1968), and also by Norris (1971), as changes with a period of 8.81 days in the He I lines were detected.

To complete the photometric information, it is included in Table 3 the UBVRI photometry of the 12 helium-weak stars of Table 2. Their UBV data is taken from the photometric catalogue compiled by Jaschek *et al.* (1972), and the R and R − I values were measured at the Cerro Tololo Inter-American Observatory in December 1974. With a photomultiplier FW 118 plus interference filters to match the R and I bands of the Johnson system.

The (B − V, U − B) array of these stars and the intrinsic color sequence taken from FitzGerald (1970) are plotted in Figure 3. The diagram shows all the He-weak stars having colors from about B2 to B6, with a maximum number of objects at B5 − B6; only one star, HD 23408, corresponds to a B7 − B8 object. The two stars marked by arrows, HD 19400 and HD 202671, are located in the region of the B6 objects, slightly different to what the Balmer line photometry suggests (B8). A similar result is derived from the (R − I, U − B) array plotted in Figure 4.

The average of our UBV measures obtained from 1965 to 1975 of the two helium-weak stars, HD 5737 and HD 125823, are contained in Table 4. The dispersion of the observed values, listed in the last three columns, suggests the possible variation of the V magnitude of the latter star, which might be associated with their spectral changes.

IV. DISCUSSION

In Table 5 the spectral types of 12 helium-weak stars inferred from the (α, β), (B − V, U − B) and (R − I, U − B) diagrams are compared with their MK spectral classification. As a rule their B − V and U − B colors correspond to earlier types compared with their MK classifications —their helium-weak characteristic was discovered this way. On the other hand, the α and β indices indicate a still earlier spectrum. But, there are two exceptions, both stars HD 19400 and HD 202671 display a very different phenomenon as the α and β indices correspond to the same spectral type object, B8, identical to the one given by the spectral classification, but with B − V and U − B colors bluer, suggesting a slightly earlier spectral type.

TABLE 3

UBVRI PHOTOMETRY OF HELIUM-WEAK STARS

HD	V	B-V	U-B	n	R	R-I	n
5737	4.31	−0.16	−0.54	11	4.32	−0.13	9
19400	5.50	−0.17	−0.48	3	5.54	−0.12	2
21699	5.48	−0.10	−0.58	4			
22470	5.22	−0.14	−0.48	5	5.25	−0.11	2
22920	5.52	−0.16	−0.57	5	5.54	−0.12	2
23408	3.87	−0.07	−0.40	9	3.84	−0.05	1
28843	(5.8)	−0.14	−0.55	4	5.76	−0.13	2
49333	6.06	−0.16	−0.66	4	6.14	−0.14	1
74196	5.58	−0.14	−0.52	4			
79158	5.31	−0.14	−0.48	4			
125823	4.41	−0.19	−0.74	12	4.45	−0.20	3
202671	5.41	−0.12	−0.50	4	5.37	−0.12	1

TABLE 4

OUR UBV PHOTOMETRY OF HD 5737 AND 125823

HD	V	B-V	U-B	n	σ_V	σ_{B-V}	σ_{U-V}
5737	4.31	−0.16	−0.52	14	±0.023	±0.012	±0.022
125823	4.42	−0.19	−0.73	20	±0.036	±0.015	±0.021

TABLE 5

SPECTRAL TYPES OF THE HELIUM-WEAK STARS DERIVED FROM FIGURES 2, 3 AND 4 COMPARED WITH THEIR CLASSIFICATION

HD	Fig. 2 (α, β)	Fig. 3 (B-V, U-B)	Fig. 4 (R-I, U-B)	Sp. Type	Q
5737	B2.5	B5	B5	B8 III	−0.42
19400	B8	B6	B6	B9 IV	−0.36
21699	B3	B5	—	B8 III	−0.51
22470	B4	B6	B6	B9 V	−0.38
22920	B2.5	B5	B5	B9 V	−0.46
23408	B3	B8	B7	B7 III	−0.35
28843	B3	B5	B5	B9 III	−0.45
49333	B3	B3	B3	B9 IV	−0.54
74196	B5	B6	—	B8 IV	−0.42
79158	B4	B6	—	A1	−0.38
125823	B2.5	B2	B3	B3 V	−0.60
202671	B8	B6	B6	B8 p	−0.41

Recently Bond and Levato (1976) have located the helium-variable stars in an intermediate position between the hotter helium-rich stars and the cooler helium-weak stars. The star HD 125823 was described

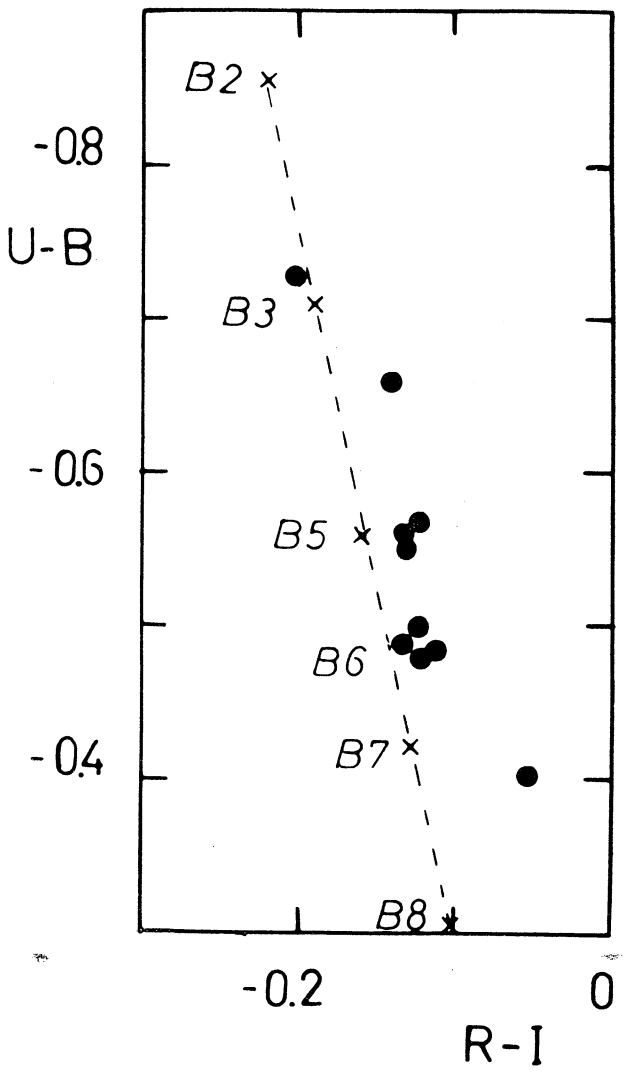

FIG. 4. (R-I, U-B) array for the helium-weak stars of Table 3, with the intrinsic color relation from Johnson (1966).

by them as a "transition object", according to the helium-line variations. They used the reddening-free index $Q = (U - B) - 0.72\ (B - V)$ to show the progression with temperature of this kind of objects. In the last column of Table 5 the values of Q are listed. The more negative value is shown by HD 125823 with $Q = -0.60$, while the others yield Q between -0.54 and -0.35. This confirms the Bond and Levato's conclusion that the helium-weak stars are found to lie in the range $Q = -0.54$ to -0.33.

It is interesting that the star HD 49333 is close to the open cluster NGC 2287 (Feinstein, Clariá and Cabrera 1977). With the assumption of membership, it becomes the brightest. Its position in the HR diagram is then peculiar as it is located in the extension of the evolutionary sequence of the cluster stars, but above the red giants. In another cluster, NGC 6475, the brightest star in the evolutionary sequence, HD 162374 is also a helium-weak object (Koelbloed 1959; Bond and Levato 1976).

As a conclusion, the evidence seems to indicate the heterogeneity of the stars having helium-weak lines. Nevertheless, more photometric and spectroscopic information is needed in order to have a clear understanding of these peculiar B-type stars.

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