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A PRELIMINARY REPORT ON PHOTOMETRIC MEASUREMENTS OF THE HELIUM LINE λ10830 A

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RESUMEN. Este trabajo está basado en ochenta y nueve estrellas, seleccionadas del Catalogo 'Bright Star Catalog'. Las observaciones se han hecho para medir un índice $\psi(25)$, en la misma forma como se definieron los índices $\alpha(16)$ y $\Lambda(9)$. En esta ocasión para medir la absorción total de la línea de helio neutro λ10830 A; se comparan nuestros resultados con las medidas de ancho equivalente determinadas por Zirin. También se efectuan algunas comparaciones con el sistema fotométrico $\alpha(16)\Lambda(9)$.

ABSTRACT. This study is based upon 89 stars taken from the Bright Star Catalog to measure the total absorption of the He I line at λ10830 A. It is defined a $\psi(25)$ index in the same fashion as the $\alpha(16)$ and $\Lambda(9)$ indices. Our results are compared with Zirin's equivalent widths, and with the $\alpha(16)\Lambda(9)$ photometric system.

Key words: PHOTOMETRY

I. INTRODUCTION

Estimates of the He I line at λ10830 A offers a convenient way of surveying the coronal emission measure of a variety of stars. This has the advantage of being easier and more economical than direct X-ray detection. An extense account of measurements of equivalent widths of this neutral helium line, and applications to Astronomy has been made by Zirin (1982).

This paper gives a description of a photometric technique to measure the He I (λ10830 A) line, in the same fashion as the $\alpha(16)$ and $\Lambda(9)$ indices (Mendoza 1973, 1975, 1979a, 1979b, 1981, 1983, and 1986). Preliminary results are shown.

II. THE OBSERVATIONS

The observations have been carried out with the 1.5 m (Johnson Telescope), and 0.84 m telescopes of the Observatorio Astronomico Nacional at San Pedro Martir, B.C., Mexico in October 1984 and June 1986.

The filters used to define the He I (λ10830 A) index, $\psi(25)$, are described in Table 1, and illustrated graphically in Figure 1. This index is defined as follows:

$$\psi(25) = k + m(b) - 0.5\,[m(a) + m(c)] \qquad (1)$$

where m(a), m(b), and m(c) are magnitudes measured through the interference filters a,b,c described in Table 1 (see also Fig. 1); k is a constant usually taken as zero. However, herein it will be determined from equivalent widths with the hope that a zero index would mean a negligible equivalent width (see below).

This $\psi(25)$ index is insensitive to the influence of interstellar reddening.

The λ10830 A line is located in a most difficult spectral region where usually detectors are not very sensitive. We provisionally have employed the same RCA 7102 photomultiplier, used by Johnson to define the RI, and 13-color photometric systems (see per example Johnson and Mitchell 1975). We have observed 89 stars so far, from O to M, spectral types; from I to V, luminosity class; and normal and abnormal stars.

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TABLE 1

ψ(25): He I (λ10830 A) Photometric System

PWL (A)	HPWB (A)	Transmission (%)	Filter designation
10771.5	31	79	a
10832.5	25	81	b
10893.0	28	78	c

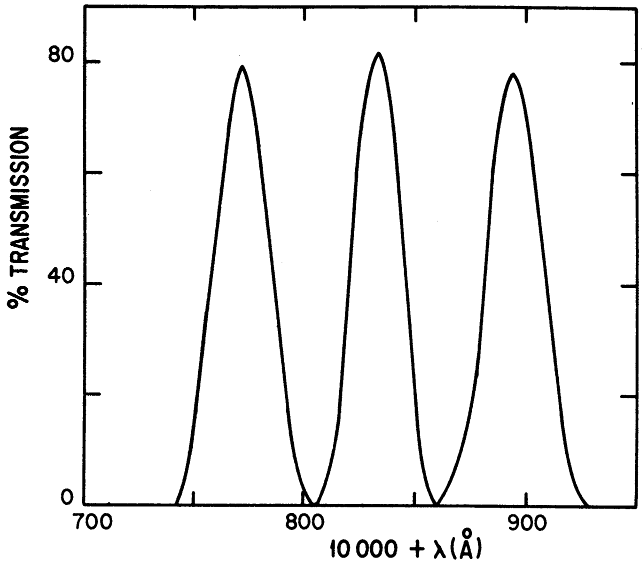

Fig. 1. Percentage of filter transmission of the ψ(25) photometric system.

The probable error of a single observation of the ψ(25) index is 0.004 mag. Zirin's data (1982) have a threshold of detectability around 30 mA which is less accurate by a factor of two, roughly, than our photometric data. However, it should be pointed out that the presence of λ10832 A water vapor line could be a cumbersome problem in photometric work. The amount of water vapor at San Pedro Observatory is between 1 and 3 mm precipitable water, most of the time (Gimmestad et al. 1972), fortunately.

The new photometric data, in magnitudes, are listed in Table 2.

III. DISCUSSION

The data contained in Table 2 comprise 31 stars which according to Zirin (1982) have all a zero equivalent width. Thus it seems reasonable to use these values to determine the constant, k, in equation (1). We obtain, after weighting the quantities by the total number of observations,

$$k = 0.167 \pm 0.005 \qquad (2)$$

Actually the values of ψ(25) given in Table 2 have been obtained applying equations (1) and (2). This means that, in the first approximation, if ψ(25) = 0, then W(mA) vanishes, probably. However, it should be noted that the great majority of the stars earlier than F0 so far observed have a negative ψ(25) index, while the great majority of the stars listed in Table 2 from F0 to M7 have a positive ψ(25) index.

At present the relationship between ψ(25) and W(mA) is not very useful because more than half of the equivalent widths of our stars are zero, and also because a significant number of the remaining stars have a variable equivalent width (Zirin 1982), and a variable ψ(25) index (see Table 2).

Between Zirin's results (1982) and the data contained in Table 2, we have 14 stars with a probable λ10830 A variable in intensity, and 12 stars suspected of variability. Thus the large number of stars with a variable λ10830 A line found by Zirin (1982) is confirmed. It is interesting to mention that the largest variation of this helium line, in our data corresponds to Algol. This large value was also found by Zirin.

The photometric data are too scanty to deduce at this stage photometric properties. However, it is interesting to note that two groups of stars, namely, the F-G type stars of luminosity class I, and the A-type stars of lower luminosity (III-V), all nearly lie in a straight line in the α(16)Λ(25) plane as shown in Figure 2. This relationship indicates that

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TABLE 2

He I (λ10830 A) Line Photometry of Bright Stars
(in magnitudes)

BS	Name	ψ (25)	n	MK	Rks
15	α And	-0.014	3	B8 IVp MnHg	
21	β Cas	0.005	5	F2 III-IV	
39	γ Peg	-0.006	5	B2 IV	
168	α Cas	0.003	5	K0 III	v:(2)
188	β Cet	0.022	3	K0 III CH-1H,K-0.5	v(2)
264	γ Cas	-0.262	5	B0.5 IVe	
337	β And	0.002	4	M0 IIIa	
403	δ Cas	-0.011	5	A5 III-IVv	
553	β Ari	-0.012	4	A5 V	
603	γ¹ And	-0.002	4	K3 IIb	v(2)
617	α Ari	0.005	4	K2 IIIab Ca-1	
622	β Tri	-0.013	4	A5 III	
681	o Cet	-0.020	3	M7 IIIe	
911	α Cet	0.007	4	M1.5 IIIa	
915	γ Per	0.003	4	G8 III + A2 V	
936	β Per	0.013	4	B8 V	v(1,2)
1017	α Per	0.007	5	F5 Ib	
1122	δ Per	0.003	5	B5 III	v:(1)
1165	η Tau	-0.005	4	B7 IIIe	
1203	ζ Per	-0.006	3	B1 Ib	v:(1)
1220	ε Per	-0.006	4	B0.5 V + A2 V	
1231	γ Eri	0.005	3	M0.5 III Ca-I Cr-I	
1457	α Tau	0.003	6	K5 III	
1577	ι Aur	-0.006	3	K3 II	v(2)
1605	ε Aur	0.001	4	F0 Iae	
1666	β Eri	-0.010	2	A3 III	
1708	α Aur	0.032	4	G5 IIIe + G0 III	v:(2)
1713	β Ori	0.039	2	B8 Iae	v(2)
1790	γ Ori	-0.001	4	B2 III	
1791	β Tau	-0.007	4	B7 III	
1829	β Lep	0.011	2	G5 II	
1852	δ Ori	-0.012	3	B0 III + O9 V	
1865	α Lep	0.004	2	F0 Ib	
1899	ι Ori	-0.006	2	O9 III	v(2)
1903	ε Ori	-0.039	2	B0 Iae	v(1)
1910	ζ Tau	0.003	4	B4 IIIpe	
1948	ζ Ori	-0.040	2	O9.5 Ibe	v:(1)
1956	α Col	-0.011	1	B7 IVe	
2004	κ Ori	-0.034	1	B0.5 Iav	
2061	α Ori	-0.008	3	M1-2 Ia-Iab	v:(2)
2088	β Aur	-0.019	3	A2 IV	
2095	θ Aur	-0.012	2	A0p Si	
2286	μ Gem	0.006	1	M3 IIIab	
2421	γ Gem	-0.012	1	A0 IV	
4932	ε Vir	0.006	2	G8 IIIab	
5056	α Vir	-0.012	5	B1 III-IV + B2 V	
5287	π Hya	-0.002	2	K2 IIIa-IIIb CN-0.5	
5340	α Boo	0.007	5	K1 IIIb CN-1	
5429	ρ Boo	0.004	2	K3 II	
5506	ε Boo	0.005	2	K0 II-III	v(1)
5603	σ Lib	0.002	2	M3 IIIa	
5744	ι Dra	0.012	2	K2 III	v:(1)
5854	α Ser	0.006	5	K2 IIIb CN-1 Fe 4143-1	
6056	δ Oph	0.007	2	M0.5 III	
6134	α Sco	-0.010	4	M1.5 Iab-Ib + B4 Ve	
6299	κ Oph	-0.002	2	K2 III	v:(1)
6418	π Her	0.005	2	K3 IIab	
6536	β Dra	0.037	2	G2 Ib-IIa	v(2)
6556	α Oph	-0.002	2	A5 III	
6603	β Oph	0.009	2	K2 III	v:(2)
6859	δ Sgr	0.001	1	K3 IIIa	
7001	α Lyr	-0.021	7	A0 Va	
7121	σ Sgr	0.016	1	B2.5 V	
7194	ζ Sgr	-0.019	1	A2 III + A4 IV	
7234	τ Sgr	0.002	1	K1 III	
7235	ζ Aql	-0.017	1	A0 Vn	
7264	π Sgr	0.013	1	F2 II	
7310	δ Dra	0.009	2	G9 III	
7417	β Cyg	0.004	2	K3 II + B0.5 V	v(2)
7525	γ Aql	0.025	2	K3 II	v(2)
7528	δ Cyg	-0.014	2	B9.5 IV + F1 V	v:(1
7557	α Aql	-0.004	8	A7 V	
7615	η Cyg	0.005	4	K0 III	v(1)
7635	γ Sge	0.002	1	M0 III	
7751	o²Cyg	0.012	2	K3 Ib + B3 V	
7776	β Cap	0.015	1	F8 V + A0	
7796	γ Cyg	0.014	3	F8 Ia	
7924	α Cyg	0.000	8	A2 Iae	
7949	ε Cyg	0.008	7	K0 III	v:(1
8162	α Cep	-0.003	1	A7 V	
8232	β Aqr	0.021	3	G0 Ib	
8308	ε Peg	-0.004	2	K2 Ib	v(2)
8322	δ Cap	-0.001	2	Amv	
8353	γ Gru	-0.008	2	B8 III	v:(1
8414	α Aqr	0.024	2	G2 Ib	v(2)
8650	η Peg	0.005	2	G2 II-III + F0 V	
8728	α PsA	-0.018	1	A3 V	
8775	β Peg	0.003	3	M2.5 II-III	
8781	α Peg	-0.013	5	B9 V	

Remarks to Table 2: v, variable; v: suspected of variability; (1) this photometry; (2) Zirin (1982).

for these pair of stellar groups, the stronger the absorption in the Balmer hydrogen Hα line, the weaker the absorption in the neutral helium line at λ10830 A. Perhaps this is extended to weak emission (in He I) for the strongest absorption (in Hα).

Actually the F,G-type stars plotted in Figure 2 have a positive ψ(25), while the A-Type stars also plotted in Figure 2 have ψ(25) index from nearly zero, but negative, to negative values. For these stars, as expected, there is not a linear relationship between Λ(9) and ψ(25) photometric indices as shown in Figure 3.

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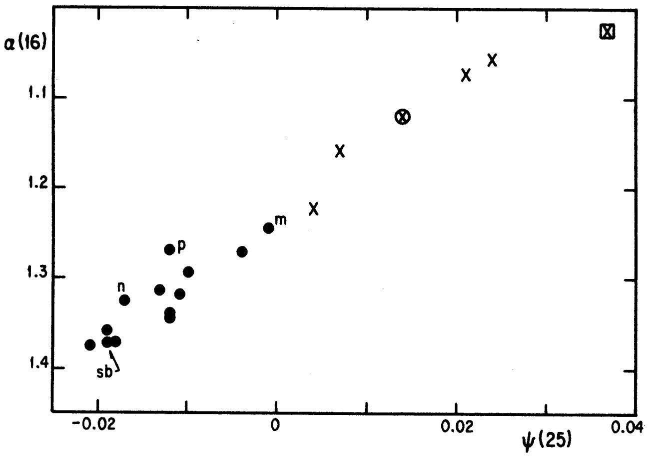

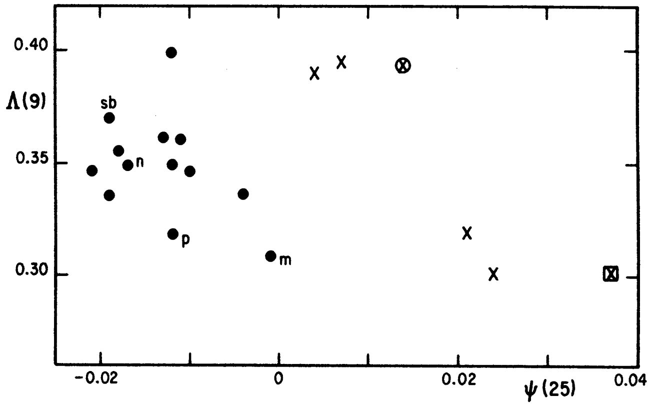

Fig. 2. The α(16)ψ(25) plane. Coding: filled circles, A-type stars of low luminosity (m, Am; n, An; p, Ap; sb, A+A -see Table 2); crosses, F, G-type stars of luminosity class Ib; crossed circle, luminosity class Ia (F8); crossed square, luminosity class Ib-II (G2).

Fig. 3. The Λ(9)ψ(25) plane. Coding as in Figure 2.

IV. CONCLUSION

The photometric technique to measure total absorptions of spectral lines has been very fruitful (cf. Strömgren 1963; Mendoza loc. cit.). This preliminary work indicates that for a given telescope, the limit magnitude reached to measure the λ10830 A line is fainter, when one uses photometric indices, than that of spectroscopic techniques. Unfortunately, no line profile is obtained through the former method.

We hope to observe this neutral helium line next year with Silicon detectors which are more sensitive than the photomultiplier employed in this preliminary work.

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