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MULTICOLOR PHOTOMETRY OF METALLIC-LINE STARS. IV. Hα AND OI OBSERVATIONS

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RESUMEN

Se dan dos sistemas fotométricos para medir las absorciones totales de la línea de hidrógeno Hα y la del triplete de oxígeno neutro (λ7774Å). Se han observado treinta y una estrellas Am en estos sistemas. Las observaciones confirman el resultado obtenido con las estrellas de las Hyadas: la fotometría Hα, OI separa nítidamente las estrellas Am de las estrellas A-normales.

ABSTRACT

Two photometric systems are given to measure the total absorption of the hydrogen line Hα and that of the neutral oxygen triplet (λ7774Å). We have observed 31 Am stars in these systems to confirm the results obtained from the Hyades stars, namely the Hα, OI photometry neatly separates Am from normal A-stars.

Key words: METALLIC-LINE STARS — NARROW BAND PHOTOMETRY — STARS, INDIVIDUAL.

I. INTRODUCTION

The A stars contain several sub-groups which depart from "normal spectra". For instance:

i) The peculiar (Ap) stars.
ii) The metallic-line (Am) stars.
iii) Herbig's (1960) emission (Ae) stars.

For a given temperature, in the A stars, the intensity of the Balmer lines *decreases* with the luminosity. On the other hand the absorption lines due to neutral oxygen *increase* with the luminosity.

We have defined photometric systems (Mendoza 1971 and 1975) to separate high luminosity stars from low luminosity ones. We have found that the photometry of the low luminosity stars showed a scatter much larger than the observational error. We observed the Hyades open cluster to study this characteristic (Mendoza 1976*a*) with the result that metallic-line stars are neatly separated from "normal" main-sequence stars.

We have observed more Am stars in two similar photometric systems to study this characteristic more detailly.

II. THE PHOTOMETRIC SYSTEMS

a) *The $\alpha(35)$, $\Lambda(16)$-photometry*

Herein, we call $\alpha(35)$, $\Lambda(16)$-photometric system that defined earlier as α,λ-photometric system (Mendoza 1975, 1976*a*, 1976*b*) since the "line"-filters have a half passband width equal to 35 and 16 Ångstroms, respectively.

b) *The $\alpha(16)$, $\Lambda(9)$-Photometry*

The $\alpha(16)$, $\Lambda(9)$-photometric systems also measures the total absorption of both the Hα-line and the triplet neutral oxygen lines at λ7774Å, through three interference filters. The "continuum"-filters are exactly those of the α,λ-system. The line filters

TABLE 1

Hα, OI-PHOTOMETRY OF METALLIC-LINE STARS

HD	Name/BS	V	B−V	U−B	α(35)	α(16)	Λ(16)	Λ(9)	n	K	m39	m43
						(in magnitudes)						
20320	ζ Eri	4.80	0.23	0.08	0.198		0.016		4,0	A5†		
23325	.....	8.58	0.34	0.16	0.215		0.024		2,0	A5†		
27628	60 Tau	5.72	0.32	0.10	0.182		0.008		5,0	A3		
27749	63 Tau	5.64	0.30	0.14	0.197	1.266	0.006	0.305	5,1	A2	F3 III	F2 V
28226	1403	5.72	0.27	0.10	0.198		0.013		4,0	A3		
28355	79 Tau	5.03	0.23	0.12	0.228		0.020		5,0	A5†		
28546	81 Tau	5.48	0.26	0.10	0.216		0.013		4,0	A5		
29140	88 Tau	4.26	0.18	0.12	0.216		0.017		5,0	A5†		
29499	1480	5.39	0.25	0.12	0.209		0.016		4,0	A5		
30210	1519	5.37	0.19	0.13	0.235		0.018		4,0	A2		
33204	1670	5.94	0.28	0.05	0.198		0.010		4,0	A5		
33254	16 Ori	5.43	0.24	0.14	0.224		0.006		4,0	A2	F0 III	F2 V
40536	2 Mon	5.03	0.19	0.16	0.230		0.022		3,0	A6†		
40932	μ Ori	4.13	0.16	0.11	0.226		0.017		0,6	A2		
76756	α Cnc	4.26	0.13	0.15	0.239	1.326	0.029	0.348	10,5	A5		
78209	15 UMa	4.48	0.27	0.12	0.202	1.283	0.008	0.310	3,5	A2	F0 III	F0 V
78362	τ UMa	4.67	0.35	0.15	0.176	1.248	0.010	0.325	3,2	A4	F3 III	F4 IV-V
95310	49 UMa	5.08	0.24	0.17	0.189	1.263	0.029	0.342	3,2	F0		
95608	60 Leo	4.42	0.05	0.05	0.160		0.013		6,0	A1†		
103877	......	6.80	0.38	0.16	0.150	1.210	0.004	0.308	2,4	A7	F5 Ib	F5 IV
104513	67 UMa	5.24	0.28	0.09	0.187		0.023		1,0	A7†		
107168	8 Com	6.27	0.17	0.14		1.320		0.333	0,3	A8†		
108486	......	6.69	0.17	0.09		1.336		0.324	0,3	A3		
108642	4750	6.54	0.18	0.11		1.302		0.330	0,3	A2		
108651	4751	6.65	0.22	0.08		1.315		0.318	0,3	A2		
126504	5401	5.82	0.31	0.13		1.255		0.305	0,1	A2	F2 III	F3 V
159560	ν^2 Dra	4.86	0.28	0.07	0.192	1.260	0.009	0.314	1,3	A4		
197461	δ Del	4.44	0.32	0.10	0.165	1.274	0.023	0.333	2,3	A7		
206088	γ Cap	3.67	0.32	0.21	0.186		0.021		2,0	A9	F3 III	F4 V
206546	8293	6.23	0.27	0.18	0.224		0.015		2,0	A3	F0 III	F2 V
220003	8877	6.05	0.43	0.16	0.147		−0.007		2,0	A5	F4 II	F4 IV

have a half passband width equal to 16.2Å for the hydrogen line and 9.0Å for the oxygen line. Their peak wavelengths are λ6567.4Å and λ7776.4Å, respectively.

c) *The Observations*

The observations have been carried out with the 40-inch telescope at Tonantzintla in 1975 and 1976. The results are summarized in Table 1 for 31 metallic-line stars taken from Mendoza's Catalogue (1975). The columns of Table 1 list: first, the Henry Draper Catalogue number; second, the name of the star or the BS number; third through fifth, the UBV photometry taken from Mendoza (1975, 1976*a* and 1976*c*); sixth through ninth, the α(35), α(16), Λ(16) and Λ(9)-photometric indices (in magnitudes); tenth, the number of independent observations in the (α(35), Λ(16)) and (α(16), Λ(9))-photometries, respectively; eleventh the spectral type derived from the K-line of CaII; twelfth the violet type and luminosity class derived from the luminosity-sensitive features located near λ3900; and last, the blue type and luminosity class derived from the features concentrated around the G-band. The m39 and m43 types were taken from Abt and Morgan (1976). Herein, these stars are named Morgan's group. The K-type plus the symbol † indicates that the object is a borderline metallic-line star.

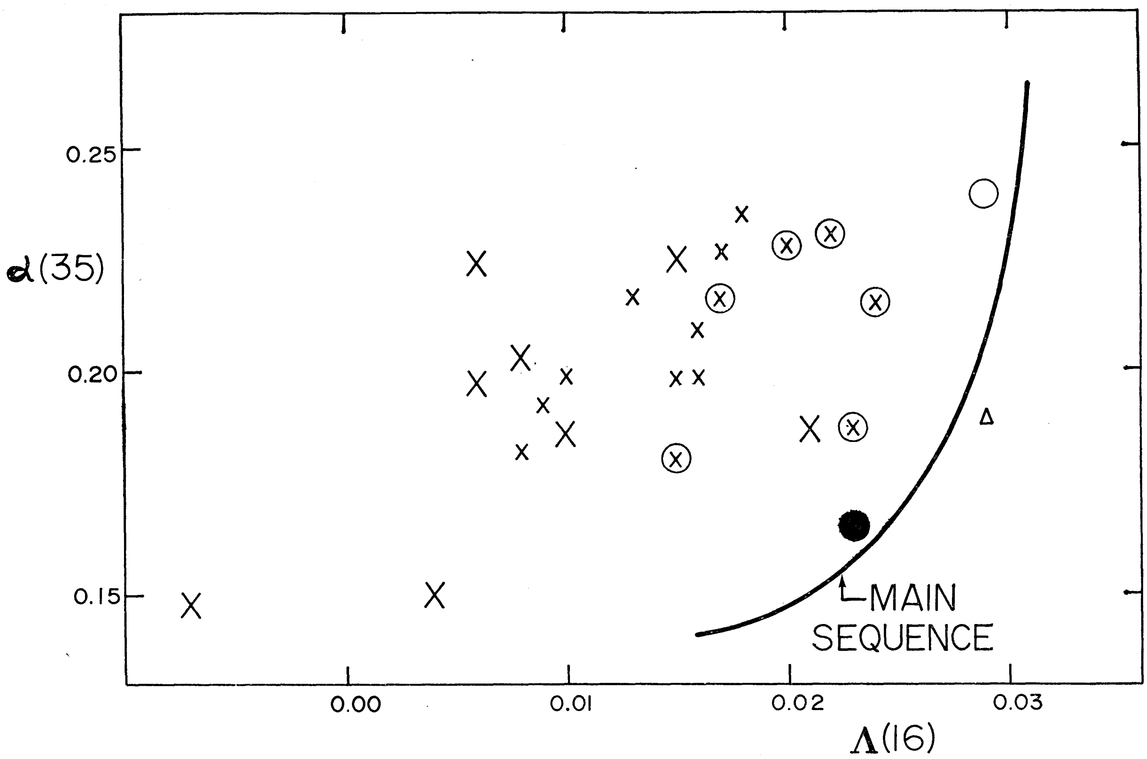

FIG. 1. The (Λ(16), α(35))-array for Am stars. Crosses represent metallic-line stars; large crosses, Morgan's group; crossed circles, borderline metallic-line stars; solid line, main-sequence; the open circle, the filled circle and the triangle represent the stars α Cnc, δ Del and 49 UMa, respectively.

d) *(OI, Hα)-arrays*

The (λ,α)-diagram for the early type Hyades stars shows a neat separation of the Am stars from the remaining types (*cf.* Mendoza 1976*a*). We have observed in this system 26 stars, listed in Table 1. These stars have been plotted in Figure 1, wherein Morgan's stars are represented as large crosses; border-line metallic-line stars, as crossed circles; other Am as crosses; α Cancri, as an open circle; δ Delphini, as a closed circle; and 49 Ursae Majoris, as a triangle.

We have also observed in the α(16), Λ(9)-photometric system 13 stars listed in Table 1. These stars have been plotted in Figure 2. The symbols have the same meaning as in Figure 1.

The solid line in Figures 1 and 2 stands for a mean main-sequence, mainly Hyades stars in Fig. 1 (Mendoza 1976*a*) and field stars in Fig. 2 (Mendoza 1976*c*). Eight stars have been observed in both photometric systems.

Least squares solutions indicate that the slopes between α(16) and α(35) is 1.4 and that of Λ(9) and Λ(16), 1.5, approximately.

III. CONCLUSION

Table 1 lists different kinds of metallic-line stars, with strong characteristics as some of Morgan's group; with mild characteristics as the Pleiades borderline metallic-line star (Mendoza 1956); early and late Am, and so on. This is reflected on the scatter shown in Figures 1 and 2. The results of the hydrogen and oxygen line photometries can be derived readily from these figures. The stars plotted in both figures fall in the same place, taking into account the different resolution and observational errors, except δ Delphini. We suspect this star has a variable α-index (Λ-indices did not change during the observations).

Morgan's group are extremely well separated from normal main-sequence (OI, Hα-arrays) A-stars, ex-

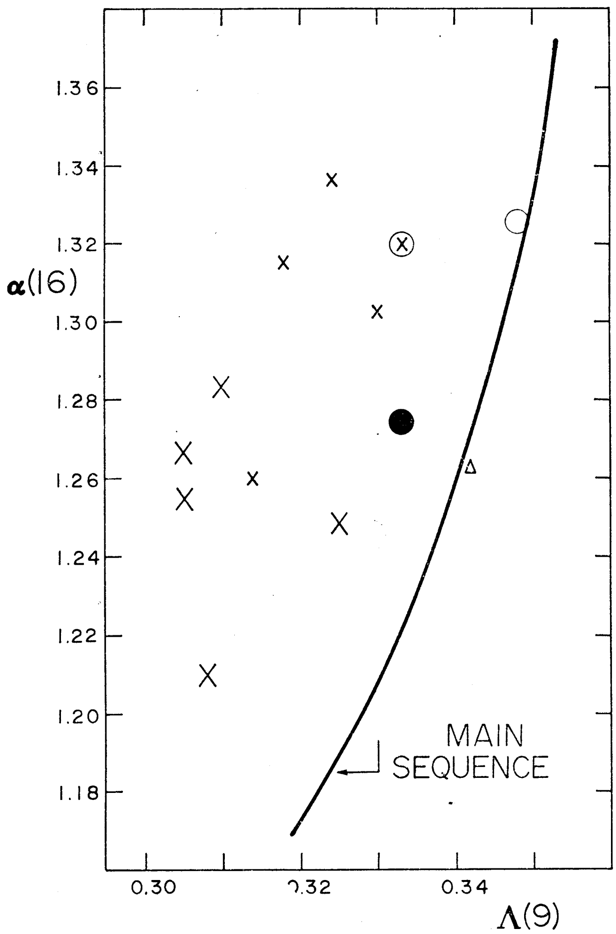

FIG. 2. The (Λ(9), α(16))-array for Am stars. The symbols have the same meaning as in Fig. 1.

cept γ Capricorni, which shows a very strong SrII (λ4077Å) —see Abt and Morgan 1976— in addition to having the latest K-type of the group (A9); nevertheless, it is also neatly separated from the main-sequence, but closer to the borderline metallic-line stars than to the "classical" Am.

The equivalent width of the neutral oxygen multiplet at λ7774Å is much larger in stars of high luminosity than in those of low luminosity (Mendoza 1971). This strengthening of the lines has been interpreted in terms of an increase in microturbulence in the lower density atmospheres (Osmer 1972). However, Johnson *et al.* 1974 show that in Canopus (F0 Ib) the observations are well fitted with a kinetic equilibrium (non-LTE line formation theory). On the other hand, subsurface diffusion models may explain the iron enhancements found for the Am class (see, for instance, Smith 1974). It should be also noted that Sargent and Searle (1962) found that several Ap stars are oxygen-deficient. Michaud (1970) has suggested that difussion processes are responsible for most of the abundance anomalies observed in Ap stars. Radiation pressure leads to overabundances while gravitational settling to underabundances. Provisional Hα, OI-photometry of Ap stars (Mendoza 1976*c*) indicates that the lambda-indices of Am stars lie between those of Ap stars and "normal" main-sequence A stars. Thus, for low luminosity A-type stars (classes IV and V), the strength of the neutral oxygen triplet at λ7774Å may be interpreted as a manifestation of the oxygen abundance of the observed atmospheric layers; and for classes I and II it is an indicator of the luminosity of the star.

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