

H $\alpha$  AND OI PHOTOMETRY OF Ap STARS

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## RESUMEN

Se da la fotometría  $\alpha(16), \Lambda(9)$  de veintitrés estrellas Ap. Los resultados muestran que las estrellas Ap se separan considerablemente de las estrellas normales de tipo A, en el plano  $\alpha(16), \Lambda(9)$ . Las estrellas Am y Ap forman una secuencia (con poco traslape) en H $\alpha$ , de menor a mayor absorción. Esta secuencia es similar a la formada por las estrellas normales. Las estrellas A-normales, Am y Ap forman una secuencia en OI prácticamente sin traslape. Las primeras tienen el índice  $\Lambda(9)$  más intenso, y las últimas el menor.

## ABSTRACT

$\alpha(16), \Lambda(9)$  photometry of 23 Ap stars is presented. The results indicate that Ap and normal A-stars are neatly separated in the  $\alpha(16), \Lambda(9)$ -plane. The Am and Ap form a continuous sequence in  $\alpha(16)$  with strongest absorption for the Ap stars. A similar sequence is defined by the normal main sequence A-stars. The normal A, Am and Ap-stars also form a continuous sequence in  $\Lambda(9)$ . The strongest absorption corresponds to the normal A-stars, the weakest to the Ap stars.

*Key words:* NARROW BAND PHOTOMETRY — PECULIAR A-STARS — STARS, INDIVIDUAL.

## I. INTRODUCTION

There are several kinds of peculiarities among the type-A stars which make their stellar spectra depart from normality. The classical Ap stars (Bp and Ap) have strong magnetic fields and bizarre chemical composition. The most frequently encountered of the peculiar A stars are the 'silicon', 'strontium', and 'manganese' groups. These elements are overabundant. The abundance anomalies also include excesses of rare-earths, osmium, platinum, mercury, phosphorus, gallium, yttrium, xenon, possibly uranium, and many others elements.

Theories on surface nuclear reactions, non nuclear processes and selective accretion from the interstellar medium have been proposed to explain the abundance anomalies observed in the Ap stars.

In this paper we show the  $\alpha(16), \Lambda(9)$  photometry of 23 possibly Ap stars.

## II. THE OBSERVATIONS

The  $\alpha(16), \Lambda(9)$  photometric system has been outlined (Mendoza 1976). A full definition of it will be published later. Herein, we recall that the H $\alpha$ -system measures the total absorption of the hydrogen line H $\alpha$ , through three interference filters with the characteristics shown in Table 1. The OI-system measures the total absorption of the neutral oxygen triplet at  $\lambda 7774\text{\AA}$ , also through three interference filters with the characteristics also shown in Table 1. In each system one filter measures the 'line' ( $F_l$ );

TABLE 1  
H $\alpha$ , OI-FILTERS

| S            | $F_b(\lambda)$ | $F_l(\lambda)$ | $F_r(\lambda)$ | $F_b(W)$ | $F_l(W)$ | $F_r(W)$ |
|--------------|----------------|----------------|----------------|----------|----------|----------|
| $\alpha(16)$ | 6497.0         | 6567.4         | 6639.0         | 37.0     | 16.2     | 38.0     |
| $\Lambda(9)$ | 7747.7         | 7776.4         | 7805.3         | 14.0     | 9.0      | 12.5     |

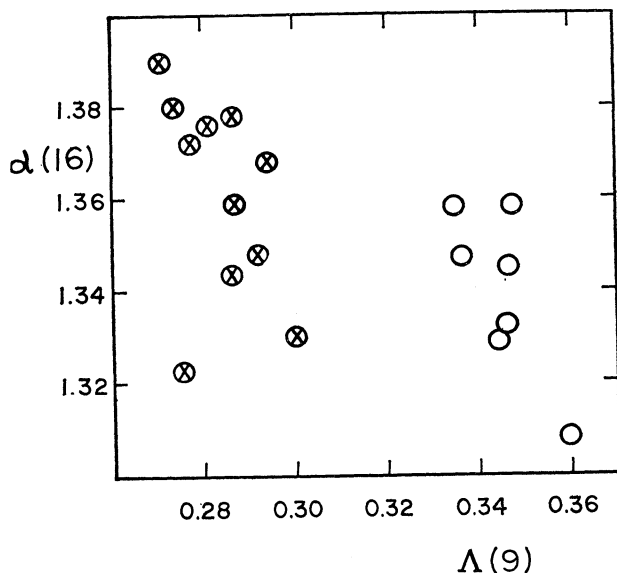


FIG. 1. The  $\Lambda(9)$ ,  $\alpha(16)$ -array for Ap stars. Open circles, represent normal A0V-A7V type stars; crossed circles, Ap stars with  $\alpha(16) > 1.32$  (see Table 1).

and two filters, the continuum on each side of the line ( $F_b$  and  $F_r$ ). The first column of Table 1 contains the name of the photometric system; columns second through fourth, the peak wavelengths (in Angstroms) of the 'blue-continuum',  $F_b(\lambda)$ , the 'line'  $F_l(\lambda)$ , and the 'red-continuum',  $F_r(\lambda)$  respectively; the last three columns, the half passband (in Angstroms) of each of the former filters, respectively. The observations have been carried out with the 40-inch telescope at Tonantzintla in 1976 and 1977. The results are summarized in Table 2 for 23 possibly Bp and Ap stars. The columns of this table contain: first, the BS number; second, the name of the star; third the spectral type; fourth, the Ap-group; fifth through seventh, the UBV-photometry; eighth, the  $\alpha(16)$ -index; ninth the  $\Lambda(9)$ -index; and last, the number of independent observations in the  $\alpha(16)$ ,  $\Lambda(9)$ -photometry. All the photometry is given in magnitudes.

### III. DISCUSSION

The  $\alpha(16)$ ,  $\Lambda(9)$ -indices measure the total absorption of the  $H\alpha$ -line, and the triplet neutral oxygen lines at  $\lambda 7774\text{\AA}$ , respectively. The  $\Lambda(9)$ -index is weaker in Ap stars than in normal A-stars. To see this more easily, we have plotted in Figure 1  $\alpha(16)$

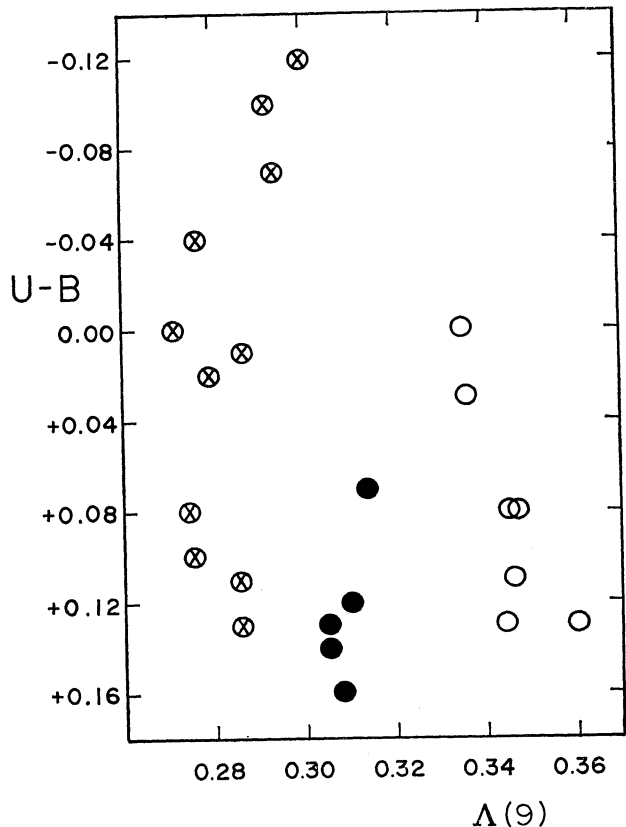


FIG. 2. The  $\Lambda(9)$ ,  $(U - B)$ -array for Ap and Am stars. The symbols have the same meaning as in Figure 1. The filled circles represent Am stars (see Mendoza 1976).

versus  $\Lambda(9)$  for both normal and peculiar A-stars. We have taken from Table 2 only those stars with  $\alpha(16) > 1.32$  mag. and from Mendoza (1977) seven normal A0V-A7V type stars. The former were drawn as crossed-circles, and the latter as open circles. The two groups are extremely well separated. The  $\Lambda(9)$ -index seems to be also weaker in Ap stars than in Am stars. To show this we have plotted in Figure 2  $U-B$  versus  $\Lambda(9)$  for the very same stars graphed in Figure 1 and in addition five classical A-metallic-line stars (cf. Mendoza 1976). The Am stars, on the average, lie between the Ap and the normal A-stars in the  $(U-B)$ ,  $\Lambda(9)$ -plane.

### IV. CONCLUSION

We aver from the data given in Table 1, and Figs. 1 and 2, the following:

TABLE 2  
H $\alpha$  AND OI PHOTOMETRY OF Ap STARS

| BS   | Name           | Sp     | Remarks      | V    | B—V   | U—B   | $\alpha$ (16) | $\Lambda$ (9) | <i>n</i> |
|------|----------------|--------|--------------|------|-------|-------|---------------|---------------|----------|
| 465  | ...            | B9p(v) | Cr, Eu, (Sr) | 6.30 | 0.10  | −0.07 | 1.368         | 0.294         | 2        |
| 873  | 21 Per         | B9p    | Si           | 5.12 | −0.01 | −0.24 | 1.278         | 0.287         | 2        |
| 954  | SX Ari         | B9p    | Si           | 5.7  | −0.10 | −0.42 | 1.218         | 0.299         | 1        |
| 1268 | 41 Tau         | B9p    | Si           | 5.2  | −0.13 | −0.47 | 1.192         | 0.289         | 2        |
| 1702 | $\mu$ Lep      | B9p    | Hg, Mn       | 3.29 | −0.11 | −0.40 | 1.216         | 0.324         | 4        |
| 3623 | $\kappa$ Cnc   | B8p    | Hg           | 5.2  | −0.11 | −0.43 | 1.216         | 0.313         | 4        |
| 3665 | $\theta$ Hya   | A0Vp?  | ...          | 3.88 | −0.07 | −0.12 | 1.330         | 0.300         | 2        |
| 4752 | 17 Com         | B9p    | Cr, Eu       | 5.29 | −0.06 | −0.10 | 1.348         | 0.292         | 4        |
| 4766 | 21 Com         | A3p    | Sr, (Cr)     | 5.46 | 0.05  | 0.10  | 1.380         | 0.274         | 3        |
| 4905 | $\epsilon$ UMa | A0p    | Cr           | 1.77 | −0.02 | 0.01  | 1.359         | 0.287         | 4        |
| 4915 | $\alpha^2$ CVn | A0p    | Si, Eu, Hg   | 2.89 | −0.12 | −0.12 | 1.285         | 0.289         | 6        |
| 5105 | 78 Vir         | A1p    | Cr, Sr, Eu   | 4.94 | 0.02  | 0.00  | 1.390         | 0.271         | 5        |
| 5747 | $\beta$ CrB    | F0IIIp | Sr, Cr, Eu   | 3.68 | 0.29  | 0.11  | 1.344         | 0.286         | 4        |
| 5971 | $\iota$ CrB    | A0p?   | Hg?          | 5.00 | −0.06 | −0.20 | 1.310         | 0.329         | 3        |
| 5982 | $\nu$ Her      | B9III? | Mn?          | 4.76 | −0.11 | −0.32 | 1.238         | 0.324         | 3        |
| 6153 | $\omega$ Oph   | A7p    | Sr, Cr       | 4.45 | 0.11  | 0.13  | 1.378         | 0.286         | 3        |
| 6234 | 45 Her         | B9p    | (Cr)         | 5.24 | −0.02 | −0.02 | 1.314         | 0.294         | 3        |
| 6254 | 52 Her         | A2p    | Sr, Cr, Eu   | 4.82 | 0.09  | 0.02  | 1.376         | 0.281         | 3        |
| 7113 | 112 Her        | B9p    | Hg           | 5.48 | −0.08 | −0.42 | 1.245         | 0.318         | 3        |
| 7167 | 10 Aql         | F0p    | Sr, Eu       | 5.9  | 0.25  | 0.08  | 1.322         | 0.275         | 3        |
| 7287 | 21 Aql         | B8p    | Si           | 5.13 | −0.07 | −0.40 | 1.183         | 0.330         | 3        |
| 8911 | $\kappa$ Psc   | A0p    | Cr, (Sr, Si) | 4.94 | 0.04  | −0.04 | 1.372         | 0.277         | 2        |
| 9031 | 108 Aqr        | B9p    | Si, Sr, Cr   | 5.16 | −0.16 | −0.43 | 1.239         | 0.292         | 2        |

- a) Ap and normal A-stars are neatly separated in the  $\alpha(16)$ ,  $\Lambda(9)$ -diagram.
- b) Ap stars have stronger H $\alpha$ -line than Am stars, on the average. They form a continuous H $\alpha$ -line sequence which, approximately covers the same range as the normal main sequence of spectral type A. The overlap is little.
- c) Ap stars have, on the average, weaker OI-lines than normal A and Am stars. The normal main sequence A-stars, the Am stars, and the Ap stars form a  $\Lambda(9)$ - index continuous se-

quence with the strongest absorption for the normal A-stars, and weakest for the Ap stars. The Am stars, on the average, lie in the middle. The overlap, if any, is little.

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