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HIGH-RESOLUTION ZEEMAN POLARIMETRY

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ABSTRACT

Photoelectric Zeeman observations have been obtained at a resolution of 0.038 Å using a line-profile scanning polarimeter together with a Fabry-Perot interferometer. Field measurements are reported for the magnetic Ap star β CrB, while negative results are found in α CMa, α^2 Lib, and ι CrB with standard errors ranging from 9 to 185 gauss.
Subject headings: polarization — stars, individual — Zeeman effect

I. INTRODUCTION

In the preceding paper (Borra and Landstreet 1973), the results of a search for weak stellar magnetic fields using a coudé line-profile scanning polarimeter are reported. This instrument is usually used with a resolution of $\Delta\lambda \sim 0.2$ Å, about the same as the width of one wing of the spectral line being observed. If the field of a magnetic star is nonuniform and the star is rotating, there will be structure in the polarization profile of the line on a scale of much less than the width of the line, from which considerable information about the distribution of the field over the stellar surface may be extracted.

II. OBSERVATIONS

To obtain polarization scans of spectral lines using high resolution without excessive loss of speed, we have combined the line profile scanning polarimeter used on the 100-inch (254-cm) telescope at Mount Wilson and described in the preceding paper with a pressure-scanned Fabry-Perot interferometer (Vaughan 1967). The interferometer is mounted after the exit slit of the spectrograph and does not change the operation of the polarimeter. This system has a resolution of 0.038 Å at 4250 Å, and is several times faster than the spectrograph alone would be at this bandpass.

The observations made with this system are listed in table 1. The standard error σ of the polarization σ_H of the field have the same meaning as in the preceding paper, except that the polarization in each line wing used to determine the longitudinal magnetic field and σ_H through equation (1) of the preceding paper is in some cases an average over several scan points in the wing.

III. RESULTS

a) β Coronae Borealis

Only in the case of the magnetic Ap star β CrB was a definite effect detected. The longitudinal fields observed (using the reduction procedure described in the preceding

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TABLE 1

HIGH-RESOLUTION ZEEMAN OBSERVATIONS

Star	V	Spectral Type	Date of Observation (JD 2,441,000+)	Spectral Line (Å)	Polarization Error σ (%)	Field Error σ_H (gauss)
α CMa	−1.47	A1 V	380.7	4254.4	0.31	24
			381.7	4254.4	0.10	9
			381.7	4254.4	0.10	9
			383.7	4254.4	0.10	9
α^2 Lib	2.75	A3–7m	382.9	4254.4	0.7	135
β CrB	3.66	F0p	381.0	4254.4	1.0	185
			382.0	4254.4	1.0	100
ι CrB	5.02	A0p	383.0	4233.17	0.85	50

paper) are $+675 \pm 185$ and $+400 \pm 100$ gauss on JD 2,441,381.0 and JD 2,441,382.0, respectively, while the field given by the magnetic curve of Wolff and Wolff (1970) for these dates are +300 and 0 gauss respectively. The agreement is not as good as might be hoped, and presumably reflects the discrepancy between our measurements and photographic ones discussed in the preceding paper. The scan made on JD 2,441,382.0 is shown in figure 1*a*. Also shown in this figure is a theoretical polarization profile calculated for that date for the field configuration determined by Wolff and Wolff (1970) from photographic Zeeman observations. The profile is calculated at each point on the disk using the analytic expression for residual intensity and circular polarization in a line derived by Unno (1956) for a Milne-Eddington model atmosphere. The contributions from the various elements of area are Doppler shifted, and the line profile and polarization profile are integrated over the visible disk. It was found possible to reproduce the observed absorption profile roughly assuming $\eta_0 = 300$ at the center of the line, and a microturbulent velocity of 4 km s^{-1}. Comparison of the observed and calculated polarization profiles shows a similarity of shape but considerable difference in amplitude. The difference may be due to inaccuracies in the magnetic field distribution assumed, to the simplifying assumptions of the theory of line formation and polarization used (Unno's expressions assume triplet splitting, for instance), or to blending. It is clear, however, that both the observed and the computed polarization profiles contain much fine structure which should be useful in determining

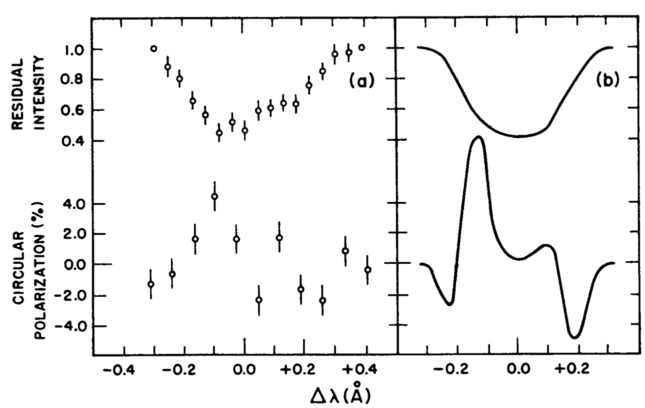

FIG. 1.—Absorption and circular polarization profile of Cr I λ4254.4 (*a*) observed on JD 2,441,382.0 in β CrB and (*b*) calculated for this phase as described in the text.

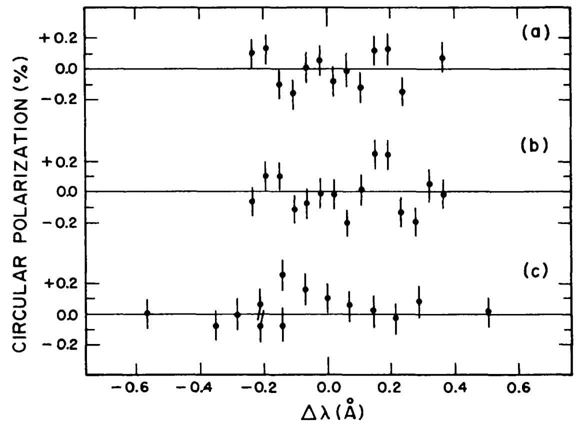

FIG. 2.—Percent circular polarization versus distance from line center Δλ observed in Cr I λ4254.4 of Sirius on (*a*) and (*b*) JD 2,441,381.7 and (*c*) JD 2,441,383.7.

details of the magnetic field distribution, and which is lost in observations with larger bandpass.

b) *α Canis Majoris*

Because Severny (1970) reports a field of 38 ± 12 gauss in Sirius, we obtained four high-resolution scans of the same line used by him. The three having the highest statistical accuracy are shown in figure 2. The field error corresponding to the polarization error σ at each point is about 20 gauss. There is no evidence for a field as large as 20 gauss on either of the two nights on which our observations are good enough to check Severny's, but any field present is likely to be variable, and may have had a small longitudinal component during our observations.

c) *α^2 Librae*

For this metallic-lined star our null result is consistent with recent conclusions from photographic observations (Conti 1969) that these stars are unlikely to have fields of much more than 3×10^2 gauss.

d) *ι Coronae Borealis*

This sharp-lined Mg-Mn star has a very peculiar distribution of mercury isotopes (Preston 1971) as well as platinum (Dworetsky and Vaughan 1973). Like other Hg-Mn stars (Conti 1970), it shows no evidence of a magnetic field. The extreme sharpness of the lines ($\Delta\lambda_{1/2} \simeq 0.13$Å for Cr) makes the high resolution obtainable with the Fabry-Perot very useful.

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