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THE LINEAR POLARIZATION OF u HERCULIS

The eclipsing variable, u Her (68 Her, HR 6431, HD 1566383, BD $+33^{o}2864$), was observed with the polarimeter described by Koch and Pfeiffer (1976) mounted on the Pennsylvania 72-cm reflector. The instrumental polarization, which was small for all bandpasses, was evaluated from the observations of 16 zero-polarization standard stars. The notation of Koch and Pfeiffer is used in the present paper. Table I lists the instrumental responses and the integration and housekeeping intervals. It may be noted that T = 2800 sec. corresponds to 0.016 P. The journal of the observations appears in Table II for which phases have been computed from the ephemeris:

Pr. Min. (hel.) = 2405830.033 + 2.051027 E.

The first purpose for obtaining the present observations was to compare and contrast the present blue polarization state of u Her against the similar data of Rudy and Kemp (1977), which are much more numerous and of greater observational weight and were obtained in the previous season. The following remarks may be made. (1) For both series most of the signal is contained in the Q-parameter. (2) The phases and magnitudes of minimum polarization are essentially the same for the two seasons. The minimum polarization of about 0.02% is consistent with the interstellar component (Mathewson and Ford 1970) to be expected at a distance of about 200 pc for the galactic coordinates of u Her. (3) For both seasons one polarization maximum of 0.06% occurs near phase 0.75 P. (4) In both sets of data a second polarization maximum occurs at phase 0.3 P. The peak-to-peak scatter of both the Oregon and Pennsylvania observations is about 0.04%. The mean of the Pennsylvania measures from 0.24 P to 0.41 P is greater than the Oregon mean by 0.02% $\pm$ 0.006%. The scatter in both data sets and the imprecision of the small systematic difference permit only a weak conclusion: the systematic difference, if

Table I. Instrumental responses and observing intervals for u Her.

Filter	$\lambda_{eff.}$ (Å)	FWHM (Å)	t (sec.)	T (sec.)
Narrow red	7450	200	1920	2800
Red	6520	850	320	840
Green	5350	800	320	840
Blue	4300	760	320	840
Ultraviolet	3710	310	1920	2800

Table II. Polarization observations of u Her.

Filter	J.D.(hel.)-2443200	Phase	Q(%)	U(%)	p(%)
Blue	49.822	0.414	-.02 (.02)	-.06 (.02)	0.06 (.02)
Green	49.840	.423	-.08 (.02)	.00 (.02)	.08 (.02)
Blue	51.778	.368	-.04 (.01)	-.02 (.01)	.05 (.01)
Red	51.799	.378	+.01 (.01)	-.04 (.01)	.04 (.01)
Red	51.814	.385	-.03 (.02)	-.07 (.02)	.07 (.02)
Blue	51.833	.394	-.05 (.02)	-.05 (.02)	.07 (.02)
Blue	64.736	.686	-.06 (.01)	+.04 (.01)	.08 (.01)
Ultraviolet	64.780	.707	+.01 (.03)	-.02 (.03)	.02 (.03)
Ultraviolet	64.820	.727	-.06 (.03)	-.06 (.03)	.09 (.03)
Blue	64.858	.745	-.056 (.009)	-.001 (.009)	.056 (.009)
Blue	75.733	.047	-.01 (.01)	+.01 (.01)	.02 (.01)
Blue	75.827	.093	-.03 (.01)	+.03 (.01)	.04 (.01)
Blue	78.637	.463	+.02 (.01)	-.02 (.01)	.02 (.01)
Narrow red	78.690	.489	+.04 (.04)	-.05 (.04)	.06 (.04)
Green	78.739	.513	-.06 (.01)	+.02 (.01)	.06 (.01)
Green	78.758	.523	-.02 (.01)	.00 (.01)	.02 (.01)
Blue	78.780	.533	-.01 (.02)	.00 (.02)	.01 (.02)
Blue	79.635	.950	-.05 (.01)	.00 (.01)	.05 (.01)
Blue	85.625	.871	-.05 (.02)	.00 (.02)	.05 (.02)

Table II. (cont.)

Filter	J.D.(hel.)-2443200	Phase	Q(%)	U(%)	p(%)
Red	85.649	.882	-.04 (.02)	-.01 (.02)	.04 (.02)
Red	85.665	.890	-.01 (.03)	-.01 (.03)	.02 (.03)
Blue	85.684	.899	-.06 (.02)	-.02 (.02)	.06 (.02)
Ultraviolet	85.736	.925	+.01 (.02)	-.01 (.02)	.02 (.02)
Blue	85.789	.951	+.04 (.01)	-.04 (.01)	.06 (.01)
Blue	90.622	.307	-.10 (.01)	-.01 (.01)	.10 (.01)
Green	90.642	.317	-.09 (.01)	+.01 (.01)	.09 (.01)
Green	90.664	.327	-.02 (.02)	.00 (.02)	.02 (.02)
Blue	90.682	.336	-.08 (.02)	-.04 (.02)	.09 (.02)
Narrow red	90.735	.362	+.04 (.06)	-.04 (.06)	.06 (.06)
Blue	90.780	.384	-.08 (.02)	+.02 (.02)	.08 (.02)
Blue	91.619	.795	-.05 (.02)	+.02 (.02)	.05 (.02)
Ultraviolet	91.731	.850	-.08 (.03)	+.03 (.03)	.08 (.03)
Blue	91.768	.868	-.04 (.02)	+.01 (.02)	.04 (.02)
Red	91.792	.879	+.02 (.01)	+.04 (.01)	.04 (.01)
Red	91.816	.891	-.04 (.02)	-.01 (.02)	.04 (.02)
Blue	91.837	.902	-.04 (.01)	.00 (.01)	.04 (.01)
Blue	98.687	.240	-.08 (.01)	.00 (.01)	.08 (.01)
Blue	98.807	.299	-.05 (.03)	-.04 (.03)	.07 (.03)
Green	98.835	0.312	-.11 (.02)	-.03 (.02)	0.12 (.02)

real, cannot be due to the familiar close binary reflection effect. (5) It is similarly true that the small systematic difference between the Pennsylvania polarizations at the two maxima cannot be due to the reflection effect. (6) Over the phase interval, 0.89 P to 0.95 P, the Pennsylvania results are 0.02% $\pm$ 0.006% greater than the Oregon mean. (7) The limiting measure by Hall and Mikesell (1950) sheds no light on possible intrinsic variability.

The second reason for obtaining the new observations was to determine a polarization spectrum. This accounts for the sequence of the data of Table II which typically permitted interpolating the blue measures to the times of those for other filters. Two procedures were used to calculate the spectrum: (1) normalize by division a non-blue measure by the interpolated blue value, and (2) establish a fictitiously constant blue polarization, correct all real blue measures to that constant value, and apply the same additive correction to the non-blue values. The two procedures yielded the identical result that, within a precision of 0.02%, the polarization spectrum of u Her is flat from λ3700 to λ7450. The wavelength dependence of the interstellar component cannot be recognized for a value as small as 0.02%. Additionally, there is no reason to suppose that a thick shell is associated with the u Her system so hydrogen self absorption should be absent. The best interpretation appears to be that electron scattering is truly the cause of the systemic polarization as Rudy and Kemp have postulated. These authors also note that the polarization should decrease with increasing wavelength if the scattering mechanism is the reflection effect seated in the cool (B5) binary component. From λ3700 to λ7450, a 35% polarization decrease is suggested by the models given in Gingerich (1969) if the reflection effect is really the cause of the scattering. The present ultraviolet and narrow red observations have not been made at the same phases. When they are corrected for the mean phase dependence of Rudy and Kemp's blue data, no polarization gradient emerges. A realistic test would have to distinguish between, say, 0.05% at λ3700 and 0.03% at λ7450. This is impossible for the present data since the error of the mean at λ7450 is $\pm$ 0.03%.

The possible intrinsic polarization variability of u Her would be qualitatively consistent with the evidence of streaming gas developed by Kovachev and Reinhardt (1975). Since the binary is no longer a ZAMS one, variability is also compatible with the statistical summary by Pfeiffer and Koch (1977). There remains only the question of what fraction of the variability is due to scattering in the circumstellar volume, and it is reasonable to suppose that a lower limit to this value is displayed by the intrinsic seasonal variability which remains poorly known at present.

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