A Search for the Regional Variations in the Wavelength Dependence of Interstellar Polarization

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THE POLARIZATION OF 19 BRIGHT, HIGHLY POLARIZED STARS was measured from March until July 1965, with a differential polarimeter installed at the Cassegrain focus of the 90-cm telescope of the Toruń Observatory in Poland. The stellar light was split by the calcite Wollaston prism into two beams falling upon the cathodes of the photomultipliers. The observations were made at eight position angles of the polarimeter differing by 45°, alternately with and without the quartz depolarizer. The yellow 2-mm Schott GG 14 and the blue Schott BG 12 (1-mm)+GG 13 (2-mm) filters were used. No optical elements except the depolarizer were placed between the Wollaston prism and the telescope mirrors.

Usually only the Stokes parameters having the larger absolute values were accurately measured. The resulting polarization ratios p_V/p_B of the Stokes parameters expressed in magnitudes, measured with yellow and blue filters, are given in the ninth column of table I. They are followed by the number of nights that the star was observed; each observation lasted about an hour. Several nearby stars from the list published in reference 1 were also observed; these observations indicate that the instrumental polarization is negligibly small.

Table I contains all the stars for which the ratio of the amounts of polarization in yellow and blue spectral regions is known with a mean error not larger than ± 0.05. It includes the observations reported in references 2 to 5, and those made at the Toruń Observatory. The results of these references are followed in table I by their mean errors. The value p_{4290} is the average of the amounts of polarization measured by Treanor (ref. 4) at 4050 Å and 4530 Å, while p_{5250} is the average of those at 5000 Å and 5500 Å. In the last column of table I the arithmetic mean of the polarization ratios listed in preceding columns is given for each star. No appreciable systematic differences between the results of different authors are found.

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TABLE I.—*Ratios of Interstellar Polarization in*

HD or cluster number	Star	^{III} deg	$\frac{E_{V-I}}{E_{V-R}}$	$\frac{p_{5160}}{p_{4300}}$ (ref. 2)	$\frac{p_{5580}}{p_{4200}}$ (ref. 3)
147165	σ Sco	351	2.20	.....	.....
147933	ρ Oph	354	2.14	.....	.....
160529		356	.....	.....	.....
149757	ζ Oph	6	2.00:	1.09 ± .03	.....
M 25	77 stars	14	.....	.....	.....
161056		18	.....	.....	1.02 ± .02
154445		19	.....	.....	1.08 ± .01
183143		53	1.89	.....	1.07 ± .01
NGC 6823	16 stars	59	2.11	.....	.....
193237	P Cyg	76	1.75:	.....	.....
194279		78	.....	.....	.....
VI Cyg	27 stars	80	1.80	.....	.....
194057		81	.....	.....	.....
198478	55 Cyg	86	1.91	.....	1.00 ± .02
197770		93	.....	.....	.....
204827		99	.....	.....	.....
207260	ν Cep	102	1.82	.....	.....
213470		104	.....	.....	.....
217476		108	1.76	.....	.....
5394	γ Cas	123	1.86:	1.11 ± .05	.....
6811	φ And	126	1.7:	0.88 ± .05	.....
7927	φ Cas	127	1.98	.....	.....
10516	φ Per	131	1.86:	.92 ± .04	.....
13402		133	.....	.....	.....
+58°400		133	.....	.....	.....
Stock 2	10 stars	133	.....	.....	.....
17378		138	1.90	.....	.....
21291	2H Cam	141	2.15	.....	1.00 ± .02
21389		142	1.96	.....	.....
25443		143	.....	.....	.....
24912	ξ Per	160	1.94	1.16 ± .05	.....
24398	ζ Per	162	2.17:	1.04 ± .02	.....
NGC 1893	19 stars	174	.....	.....	.....
43384	9 Gem	188	2.08	.....	.....
41117	χ^2 Ori	189	2.00	.....	.....
37356	near M 42	208	.....	.....	.....

[a] Value for p_{5250}/p_{4550}.

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Yellow and Blue Spectral Regions

$\frac{p_{5250}}{p_{4290}}$ (ref. 4)	p_V/p_B (ref. 5)	p_V/p_B (present paper)	Number of nights observed (present paper)	Mean value of p_V/p_B
1.13 ± .04	.....	.....	.....	1.13
1.11 ± .04	.....	.....	.....	1.11
[a] 1.10 ± .06	1.03 ± .02	.....	.....	1.06
1.08 ± .04	.....	.....	.....	1.08
.....	1.03 ± .02	.....	.....	1.03
1.13 ± .05	1.13 ± .05	1.11 ± .03	2	1.10
0.98 ± .04	1.19 ± .02	1.06 ± .02	4	1.08
1.10 ± .02	1.07 ± .02	1.09 ± .02	2	1.08
.....	1.08 ± .02	.....	.....	1.08
.....	.....	0.93 ± .05	2	.93
.....	.....	1.04 ± .03	2	1.04
.....	0.93 ± .02	.....	.....	.93
.....	.....	1.01 ± .04	2	1.01
0.95 ± .02	1.00 ± .04	1.02 ± .03	3	.99
.....	.....	1.01 ± .03	3	1.01
.....	.....	0.97 ± .02	5	.97
.....	.....	0.96 ± .04	2	.96
.....	.....	1.02 ± .04	2	1.02
0.97 ± .03	.....	0.98 ± .08	2	.97
.....	.....	.....	.....	1.11
.....	.....	.....	.....	.88
.....	1.03 ± .04	1.02 ± .02	2	1.02
.....	.....	.....	.....	.92
.....	1.03 ± .05	.....	.....	1.03
.....	1.02 ± .03	.....	.....	1.02
.....	1.09 ± .04	.....	.....	1.09
.....	.....	1.06 ± .04	1	1.06
.....	1.01 ± .02	.....	.....	1.00
.....	.....	1.00 ± .05	1	1.00
.....	.....	0.99 ± .03	1	.99
.....	.....	.....	.....	1.16
.....	.....	.....	.....	1.04
.....	1.03 ± .04	.....	.....	1.03
.....	1.08 ± .02	1.03 ± .03	3	1.06
.....	.....	1.09 ± .05	1	1.09
.....	.....	1.11 ± .05	4	1.11

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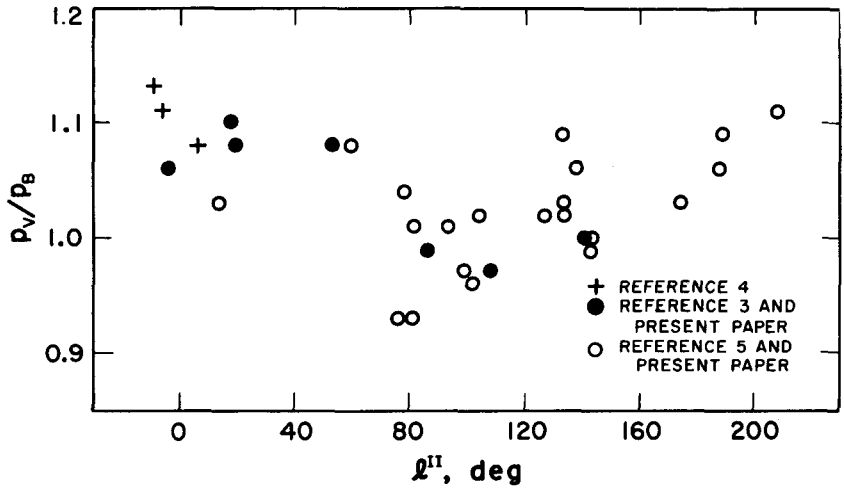

FIGURE 1.—Ratio of amount of polarization in yellow to amount in blue spectral region as a function of galactic longitude of the star.

The dependence of the mean ratios of yellow and blue amounts of polarization as a function of galactic longitude is shown in figure 1. The smallest values of this ratio occur in the Cygnus region.

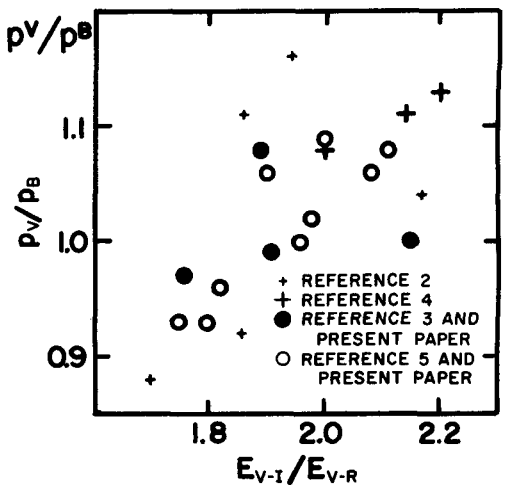

FIGURE 2.—Ratio of amount of polarization in yellow to amount in blue spectral region as a function of ratio of the color excesses E_{V-I}/E_{V-R}.

The ratio of polarizations is correlated with the color excesses ratio E_{V-I}/E_{V-R} as obtained in reference 6 in figure 2.[1] The ratios of the color

[1] *Note added in proof:* Recent observations of the wavelength dependence of interstellar polarization by G. V. Coyne and T. Gehrels (Astron. J., vol. 71, p. 355, 1966) and by K. Serkowski (unpublished) confirm the validity of this correlation.

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excesses listed in table I and plotted in figure 2 are computed by using the observed values of $V-R$ and $V-I$ and intrinsic colors listed in reference 6, 7, or 8. In order to bring into agreement the results of these papers, the corrections 0.09 and 0.05 were added to the $V-R$ and $V-I$ colors observed by the authors of reference 8. For the Orion Sword region, the ratio E_{V-I}/E_{V-R} equals about 2.04 and is only slightly larger than the average for all the sky; similarly the ratio p_V/p_B is 1.11 for the star HD 37356 situated near the Orion trapezium. The ratio E_{V-I}/E_{V-R} is independent of galactic longitude for those stars in the catalogues of references 6 and 8 for which the amount of polarization is larger than 0.020 magnitude.

The polarimeter described previously was also used at the Haute-Provence Observatory in France for attempts to measure the circularly polarized component of stellar light in the yellow spectral region. The values obtained for the Stokes parameter p_v describing the circularly polarized component of stellar light expressed in magnitudes are listed with their mean errors in table II. They are accompanied by the amount of polarization p and the position angle of the plane of vibration θ observed in the yellow spectral region with the same instrument used for the stars with measured p_v. For none of these stars does p_v exceed 0.0004 magnitude, an indication that the degree of ellipticity does not exceed 0.02 percent. This may be considered as an argument against the interstellar grains with high iron content, as these are expected to introduce an appreciable circularly polarized component into the partially plane-polarized stellar light. (See ref. 1.)

TABLE II.—*Observations of the Circularly Polarized Component of Stellar Light*

HD number	Star	p	θ, deg	p_v, magnitude
21291	2H Cam	0.073	116	$+0.0004 \pm .0003$
36371	χ Aur	.048	176	$-.0002 \pm .0002$
109358	β CVn	.001	177	$.0000 \pm .0002$
112185	ϵ UMa	.000	.....	$-.0001 \pm .0008$
144217–8	β Sco	.017	91	$+.0003 \pm .0002$
147165	σ Sco	.032	179	$-.0001 \pm .0006$
149757	ζ Oph	.030	126	$+.0001 \pm .0003$
174638	β Lyr	.016	156	$+.0001 \pm .0003$
198478	55 Cyg	.061	3	$-.0001 \pm .0003$

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