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TRUE POLARIZATION CURVES FOR BETA LYRAE

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ABSTRACT

The interstellar component of the polarization of β Lyrae has been determined and subtracted from new polarimetric observations obtained in the visual, blue, and ultraviolet light. The dependence of the intrinsic polarization on the phase is similar in all three colors The amount of the intrinsic polarization is much smaller in the ultraviolet compared to the visual and blue light. A qualitative analysis of the polarization curves supports Huang's model of the β Lyrae system.

I. INTRODUCTION

Rotationally flattened gaseous envelopes around stars produce polarized light because of the non-isotropic scattering in the non-spherical shell. For ordinary shell stars it is difficult to detect this intrinsic polarization because of the superposed interstellar polarization. However, if a shell star is a member of an eclipsing binary system, the intrinsic polarization and, therefore, the observed polarization must change periodically with the phase of the light-curve.

The brightest eclipsing binary with a gaseous envelope is β Lyrae. Variations in the polarization of the light from β Lyrae have been reported by a number of investigators (first by Öhman 1934), but only the more recent photoelectric observations show a fair agreement of the polarization curves obtained by different observers (for references see Serkowski 1965).

Shakhovskoj (1964) showed that electron scattering in the gaseous envelopes of the β Lyrae system is the only known process that can produce the observed changes in the polarization of β Lyrae. Appenzeller (1965*b*) interpreted qualitatively the polarization curve on the assumption that part of the polarized light originates in the gaseous disk of the more massive but underluminous secondary star of the β Lyrae system (Huang 1963; Woolf 1965). A similar explanation has been given by Rucinski (1966). Rucinski, however, assumed that the scattered polarized light evolves from the central part of the secondary star. However, more accurate polarization curves in different colors and a better knowledge of the interstellar component of the polarization seemed to be needed in order to investigate the problem more quantitatively. New polarimetric observations of β Lyrae have, therefore, been obtained at the Yerkes Observatory during the 1966 observing period. In addition, the components B, E, and F of ADS 11745, which are assumed to be physical companions of β Lyrae (Abt, Jeffers, Gibson, and Sandage 1962), were observed to determine the interstellar component of the polarization.

II. THE OBSERVATIONS

The 24-inch rotatable telescope (Hiltner and Schild 1965) and the observing and reduction methods described in an earlier paper (Appenzeller 1966) were used. The linearity and constancy of the polarimeter were tested frequently by observing standard stars with known polarization.

III. THE INTERSTELLAR POLARIZATION OF ADS 11745

Table 1 contains the results for the companions of β Lyrae. N is the number of observations. No significant difference in the polarization of the three companions could be found. Our results for ADS 11745B agree well with Rucinski's single observation of this star. The slow decrease of the polarization between the V and the U filter band indicates a normal wavelength dependence of the interstellar polarization.

In order to find the most likely value for the interstellar polarization of β Lyrae, a weighted mean value was calculated from all observations in Table 1 except those for U. Weights proportional to the inverse squares of the mean errors were used. The result,

$$P_{XI} = +0.0054 \text{ mag}, \qquad P_{YI} = -0.0073 \text{ mag},$$

was assumed to be of sufficient accuracy for both the V and the B color. The small systematic difference in the polarization between the B and the V filter is certainly much smaller than the cosmic scattering of the intrinsic polarization of β Lyrae. Neglecting this difference and assuming that the interstellar polarization is identical for all components of ADS 11745, one obtains a formal error of 0.0006 mag for both P_{XI} and P_{YI}.

For the interstellar polarization in the ultraviolet 0.9 P_{XI} and 0.9 P_{YI} were assumed to be the most likely values. The intrinsic polarization of β Lyrae was then calculated by subtracting the interstellar polarization from all observations.

IV. THE RESULTS

The observed and the intrinsic polarization for all new observations and for 24 older observations (Appenzeller 1965*a*) are given in Tables 2–4. In the tables θ is the position angle with respect to the equatorial coordinates. The phase has been calculated from the ephemeris given by Wood, quoted by Belton and Woolf (1965). In Figure 1 the observed amount of the polarization in U, B, and V has been plotted as a function of the phase of the light-curve. The scatter of the points in Figure 1 is too large to be explained by the observational errors alone. Table 2 shows that the differences of observations obtained at the same phase, but in different cycles, are in the average larger than the statistical variations obtained during one night. A more detailed analysis of the scattering of the points in Figure 1 shows that the average amount of the polarization and the shape of the polarization curve change randomly from period to period. This agrees well with the assumption that the observed non-periodic variations in the spectrum and light-curve originate from changes in the properties of the gaseous envelopes of the β Lyrae system (Böhm-Vitense 1954; Abt 1962). The non-periodic variations in the polarization seem to be strongest during secondary eclipse. The large increase in the average statistical error at this phase can be explained only by very fast changes of the polarization ($\Delta p \geq$ 0.0001 mag/min) near secondary eclipse.

The amount and the position angle of the intrinsic polarization is plotted against the phase in Figure 2. We call these curves "true polarization curves." The general character of the polarization curves does not depend on the wavelength. The amount of intrinsic polarization is largest in the blue, about 10 per cent smaller in yellow light, and less than half in the ultraviolet. Outside secondary eclipse no systematic change of the position angle was found. At secondary eclipse the position angle increases sharply at phase 0.45, returns to its value outside the eclipse at phase 0.50, and then decreases significantly near phase 0.55. The true values of the deviation of the position angle in Figure 2 are rather uncertain since the intrinsic polarization is very small; the non-periodic changes of the polarization and a small systematic error in the interstellar polarization have a strong influence on the computed values. However, a change in position angle in Figure 2 cannot be due to a systematic error in the determination of the interstellar polarization because of the change in sign before and after eclipse.

V. DISCUSSION

The polarization curves in Figure 2 agree well with the predictions, which have been made on the assumption that the polarized light originates from light from the primary

TABLE 1

THE INTERSTELLAR POLARIZATION OF THE COMPANIONS OF β LYRAE

Star	Filter	N	P_X	P_Y	P	m. e.	θ	m. e.
ADS 11745B	V	3	$+0^{m}.0055$	$-0^{m}.0076$	$0^{m}.0094$	$\pm 0^{m}.0009$	153°	±3°
	B	2	+0.0054	-0.0068	0.0087	±0.0009	154°	±3°
	U	2	+0.0069	-0.0044	0.0082	±0.0016	164°	±5°
ADS 11745E	No filter	5	+0.0069	-0.0084	0.0108	±0.0020	155°	±6°
ADS 11745F	No filter	5	+0.0015	-0.0068	0.0070	±0.0024	141°	±10°

TABLE 2

OBSERVATIONS OF β LYRAE WITH THE V FILTER

J. D. 2430000+	Phase	Observed Polarization				Intrinsic Polarization	
		P	m. e.	θ	m. e.	P	θ
8613.647	0.772	$0^{m}.0155$	$\pm 0^{m}.0007$	158°4	±1°7	$0^{m}.0068$	165°4
8616.622	.002	.0150	.0004	158 2	1.0	.0063	165.5
8621.711	.396	.0113	.0004	160.3	1.3	.0034	1.1
8622.619	.466	.0072	.0002	155.5	1.2	.0019	54.2
8625.607	.697	.0173	.0005	161.0	1.0	.0090	168 9
8627.665	.857	.0141	.0005	158.5	1.2	.0055	167.4
8629.676	.012	.0162	.0003	162.7	0.7	.0082	173.2
8631.726	.171	.0156	.0012	156.1	2.7	.0066	160.0
8633.619	.317	.0142	.0003	158.4	0.7	.0055	167.1
8634.579	.392	.0130	.0006	155.0	1.8	.0040	159.0
8636.611	.549	.0114	.0002	157.5	0.7	.0028	171.6
8637.579	.624	.0148	.0007	160.0	1.7	.0064	169.7
8638.579	.701	.0155	.0004	159.2	0.9	.0069	167.0
8639.587	.778	.0138	.0005	159.7	1.2	.0054	170.8
8641.623	.936	.0147	.0006	161.6	1.3	.0066	173.2
8643 585	.088	.0130	.0006	162.2	1.7	.0052	178.5
8648.615	.477	.0078	.0003	151.3	1.4	.0013	74 8
8650.580	.629	.0153	.0006	158.4	1.4	.0066	165.6
8652.563	.783	.0138	.0002	160.7	0.4	.0056	173.1
8655.556	.014	.0161	.0004	160.2	1.0	.0C77	168.5
8658.563	.247	.0145	.0006	157.8	1.5	.0058	165.1
9264.757	.121	.0134	.0004	158.3	0.8	.0048	168.0
9264.774	.122	.0133	.0003	158.5	0.5	.0047	168 9
9266.812	.280	.0166	.0003	158.1	0.4	.0079	163.6
9266.826	.281	.0165	.0004	158.9	0.6	.0078	165.6
9267.844	.360	.0167	.0004	159.5	0.6	.0082	166.5
9267.858	.361	.0165	.0002	160.2	0.3	.0080	168.1
9278.643	.196	.0138	.0003	158.5	0.6	.0051	167.8
9278.655	.197	.0145	.0005	158.3	1.0	.0058	166.3
9278.669	.198	.0146	.0005	160.0	1.0	.0062	170 0
9278.672	.199	.0137	.0004	160.5	0.9	.0055	172.8
9283.644	.582	.0142	.0006	154.4	1.1	.0052	156.5
9283.684	.585	.0141	.0009	154.1	1.8	.0050	155.7
9283.693	.585	.0136	.0003	154.7	0.6	.0046	157.7
9283.705	.586	.0146	.0004	156.0	0.8	.0057	160.4
9283.718	.587	.0139	.0002	154.1	0.4	.0049	155.7
9286.665	.815	.0128	.0004	156.0	0.9	.0039	162.6
9286.677	.816	.0134	.0003	156.7	0.7	.0046	163.6
9286.687	.817	.0138	.0003	154.6	0.7	.0047	157.2
9301.753	.983	.0185	.0005	157.9	0.8	.0097	162.3
9301.767	.984	.0186	.0006	159.1	0.8	.0099	164.5
9305.767	.293	.0164	.0005	159.6	0.8	.0079	166.9
9305.781	.294	.0167	.0007	159.4	1.2	.0081	166.3
9306.800	0.373	0.0169	±0.0010	158°8	±1°7	0.0083	165°0

TABLE 2 - Continued

J. D 2430000+	Phase	Observed Polarization				Intrinsic Polarization	
		P	m. e.	θ	m. e.	P	θ
9306. 819	0. 374	$0^m.0160$	$\pm0^m.0005$	158°8	±0°9	$0^m.0073$	165°7
9307. 762	. 448	. 0073	. 0014	168. 7	5. 4	. 0047	36. 4
9307. 773	. 449	. 0075	. 0024	153. 6	9. 0	. 0016	61 4
9307. 856	. 455	. 0047	. 0022	159 6	13. 3	. 0046	56. 7
9308. 646	. 516	. 0150	. 0008	159. 5	1. 5	. 0065	168. 3
9313 752	. 911	. 0140	. 0007	154. 5	1. 5	. 0050	157. 0
9313 766	. 912	. 0135	. 0007	160. 3	1. 4	. 0052	173 1
9314 604	. 977	. 0156	. 0005	162. 2	0 8	. 0076	173. 0
9314. 771	. 990	. 0160	. 0007	163. 3	1 2	. 0082	174. 5
9314 785	. 991	. 0163	. 0004	163. 4	0. 7	. 0085	174. 3
9314 853	. 996	. 0161	. 0005	166. 7	0. 9	. 0090	0. 2
9318 733	. 297	. 0159	. 0003	160. 5	0 6	. 0075	169 3
9318. 750	. 298	. 0158	. 0005	159. 4	0. 9	. 0073	167. 1
9318 843	. 305	. 0152	. 0004	158. 4	0 7	. 0065	165 6
9319. 698	. 371	. 0137	. 0009	153. 3	1. 8	. 0047	153. 5
9319 720	. 373	. 0138	. 0008	160 2	1 6	. 0055	172. 0
9319 779	. 377	. 0149	. 0007	157. 9	1. 4	. 0062	164 9
9319 831	. 381	. 0156	. 0010	155. 2	1. 8	. 0066	158. 0
9323. 601	. 672	. 0154	. 0006	159. 5	1. 1	0069	167. 9
9323 708	. 681	. 0165	. 0004	158 9	0. 6	. 0079	165. 5
9323. 727	. 682	. 0169	. 0004	158. 3	0. 6	. 0082	163. 9
9323. 770	. 686	. 0155	. 0003	159. 4	0. 6	. 0069	167 5
9323 829	690	. 0165	. 0003	159. 4	0. 5	. 0079	166 4
9326. 656	. 909	. 0130	. 0008	156. 6	1. 8	. 0041	164 0
9326 693	. 913	. 0130	. 0004	156. 7	0. 9	. 0041	164 3
9326. 705	. 914	0130	. 0003	155. 8	0. 7	. 0041	161 5
9326 800	. 920	. 0127	. 0010	153. 2	2. 2	. 0036	153 3
9327 628	. 985	. 0183	. 0003	157 0	0 4	. 0095	160 7
9327. 669	. 988	0166	. 0012	158. 6	2. 0	. 0079	164 9
9327. 683	. 989	. 0166	. 0007	160. 6	1 1	. 0082	168. 7
9327. 774	. 996	. 0165	. 0007	159. 9	1. 1	. 0080	167 4
9327 866	. 005	. 0169	. 0010	160. 0	1 6	. 0084	167 3
9328 697	. 067	. 0163	. 0018	156 5	3. 0	. 0074	160. 6
9328 709	. 068	0158	. 0006	160. 3	1. 1	. 0074	169 1
9330. 644	. 218	0147	0005	158 7	1 0	0061	166 9
9330. 658	. 219	. 0142	. 0004	157. 5	0. 7	. 0054	164. 8
9331. 630	. 294	. 0176	. 0004	158. 6	0 6	0089	164. 2
9331 676	297	0175	. 0003	158. 6	0 5	. 0088	164 1
9332. 605	. 370	. 0165	. 0005	159. 0	0 8	. 0079	165 7
9332. 651	. 373	0163	. 0004	160 5	0. 6	. 0079	168. 9
9332 663	. 374	. 0168	0005	156 8	0. 9	. 0079	160 9
9332. 699	. 377	. 0170	. 0006	156. 3	0 9	. 0081	159. 7
9340. 685	. 993	0166	. 0009	159. 3	1. 6	0080	166. 3
9340 685	. 994	. 0173	. 0009	159. 4	1. 4	. 0087	165 9
9342 647	. 146	. 0125	. 0005	155 9	1. 2	. 0036	162 8
9342 659	. 147	. 0126	. 0005	155 7	1. 0	. 0037	161 8
9346. 747	. 463	0132	. 0019	163. 2	4 2	. 0057	179 7
9346 759	. 464	0105	. 0013	163. 2	3. 4	. 0037	11. 9
9347. 644	. 533	. 0126	. 0013	152 4	2. 8	0035	150 2
9347. 686	536	. 0136	. 0004	154 9	0 7	. 0047	158 2
9377. 622	. 851	. 0141	. 0005	158 2	1. 0	0054	166 5
9377. 637	. 852	. 0139	. 0006	159. 5	1. 2	. 0055	170 1
9379. 604	005	. 0162	. 0008	159. 5	1. 4	. 0076	167. 1
9379. 616	. 006	. 0174	. 0009	162. 7	1. 4	. 0093	171 9
9387. 604	. 624	. 0158	. 0006	156. 2	1. 1	. 0069	160 1
9387. 615	. 625	. 0165	. 0007	157. 4	1. 1	0077	162 4
9400. 582	. 627	. 0160	. 0008	157 5	1. 4	. 0072	162 9
9400. 594	0. 628	0. 0155	±0. 0010	158°6	±1°8	0 0068	165°8

TABLE 2 - Concluded

J. D. 2430000+	Phase	Observed Polarization				Intrinsic Polarization	
		P	m. e.	θ	m. e.	P	θ
9401. 580	0. 704	0.^{m}0164	±0.^{m}0011	159°9	±1°8	0^{m}0079	167°6
9401. 592	. 705	. 0169	. 0009	158. 4	1. 5	. 0082	164. 2
9404. 521	. 932	. 0148	. 0004	156. 8	0 8	. 0059	162. 3
9404. 533	. 933	. 0153	0005	156 9	0. 8	. 0065	162. 0
9404. 624	. 940	. 0156	. 0009	156 7	1. 6	. 0053	161 5
9404 639	. 941	. 0150	. 0006	159 9	1. 1	. 0066	169. 3
9405. 624	. 018	. 0177	. 0012	163 3	1. 8	. 0097	172 6
9405. 637	. 019	. 0180	. 0008	164. 2	1 3	. 0102	173 8
9405 663	. 021	. 0183	. 0014	164 1	2 2	. 0105	173 4
9406. 523	. 087	. 0136	. 0005	158. 6	1. 1	. 0050	168 5
9406. 534	. 088	0126	. 0007	159 1	1. 5	. 0042	172 1
9410. 563	. 399	. 0127	. 0005	154. 7	1 0	0037	158 5
9410. 576	. 400	0131	. 0005	154 7	1 0	0041	157 8
9418. 556	. 017	. 0154	0011	156 6	2. 0	0065	161. 4
9418. 571	. 018	. 0159	0014	155. 6	2. 6	. 0070	158 8
9423 542	. 403	. 0139	. 0008	157 2	1 5	0051	164 2
9423 556	. 404	. 0135	. 0005	159. 0	1. 1	. 0049	164. 7
9424. 513	. 478	. 0107	. 0007	159. 7	1. 9	. 0028	3. 6
9424. 528	. 479	. 0107	. 0004	159 8	1. 0	. 0028	3. 6
9424. 583	. 483	. 0118	. 0007	161. 9	1. 7	. 0041	2. 2
9424 596	484	. 0122	. 0011	158. 2	2. 5	. 0036	171 0
9425 505	. 555	. 0120	. 0005	153 7	1 3	. 0029	155 4
9425. 519	556	. 0124	. 0010	153 1	2 2	. 0034	152 9
9426 509	633	. 0157	. 0005	157. 5	0. 9	. 0069	163. 1
9426. 521	0. 634	0. 0156	±0. 0004	158°5	±0°7	0. 0070	165°3

TABLE 3

OBSERVATIONS OF β LYRAE WITH THE B FILTER

J D. 2430000+	Phase	Observed Polarization				Intrinsic Polarization	
		P	m. e.	θ	m. e.	P	θ
9266. 856	0. 283	0^{m}0187	±0.^{m}0007	160°1	±1°0	0.^{m}0102	166°3
9301 781	985	. 0204	. 0006	156. 3	0. 8	. 0114	158. 8
9305. 798	. 295	. 0184	. 0004	156. 5	0. 5	. 0094	159. 6
9306. 833	. 375	. 0182	. 0004	158. 4	0. 6	. 0094	163 4
9307. 787	. 450	. 0054	. 0019	171. 5	10. 1	. 0057	45. 9
9313 780	. 913	. 0135	. 0004	158 7	0. 9	. 0049	168. 9
9314 802	. 992	. 0185	. 0008	165. 9	1. 2	. 0111	176. 2
9318 785	. 301	0164	. 0007	158. 9	1. 2	. 0078	165. 5
9319. 745	. 375	. 0166	. 0004	153 0	0. 7	. 0076	152. 8
9323 741	. 683	. 0176	. 0004	159. 3	0. 6	. 0090	165. 4
9326 719	915	. 0128	. 0005	156. 0	1 0	. 0039	162 5
9327. 696	. 990	. 0197	. 0009	159. 1	1. 3	. 0110	163. 9
9328 722	069	0160	. 0007	159. 5	1. 2	. 0074	167. 2
9330. 672	. 220	. 0167	. 0007	159. 6	1 1	. 0081	166. 7
9331. 688	. 298	. 0176	. 0005	160. 0	0. 7	. 0091	166 8
9332. 676	. 375	. 0164	0015	156. 1	2. 6	. 0074	159. 6
9342 675	. 148	. 0133	. 0004	154 9	0. 9	. 0043	158 4
9346. 772	465	. 0114	0011	162. 4	2. 7	0040	5 3
9387. 626	626	. 0163	. 0006	158. 7	1. 0	. 0076	165. 3
9400 550	. 625	0171	. 0006	158. 1	0. 9	. 0083	163 4
9400. 608	. 629	. 0171	. 0007	159. 6	1. 0	. 0085	166. 5
9401 556	. 702	. 0179	. 0007	158. 9	1. 0	. 0092	164. 5
9401 567	703	. 0181	. 0008	159. 3	1. 2	. 0095	165. 1
9404 548	934	. 0151	. 0006	158. 7	1. 0	. 0065	166 5
9404 563	935	. 0160	. 0008	159 2	1 4	0074	166. 7
9405 609	016	. 0188	0009	164. 7	1. 4	0111	174. 0
9406. 548	0. 089	0 0134	±0 0007	159°8	±1°5	0 0050	171°9

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TABLE 3 - Concluded

J D. 2430000+	Phase	Observed Polarization P	m e.	θ	m. e.	Intrinsic Polarization P	θ
9410. 525	0. 396	$0^{m}.0145$	$\pm 0^{m}.0007$	154°.4	±1 4	$0^{m}0055$	156°.4
9410. 544	. 397	. 0137	. 0004	153 4	0. 7	. 0046	153. 8
9418. 542	. 016	. 0161	. 0007	153. 6	1. 2	. 0071	154. 0
9423 516	. 401	. 0143	. 0007	157. 1	1. 3	. 0055	163. 5
9423. 530	. 402	. 0142	. 0005	157. 0	1 0	. 0053	177. 2
9424. 541	. 480	. 0107	. 0008	157. 8	2. 2	. 0023	177. 2
9424. 554	. 481	. 0117	. 0011	159 7	2 6	. 0035	177. 2
9425 532	. 558	. 0139	0006	151. 7	1 2	0049	148. 9
9425. 547	. 559	. 0138	0007	155. 0	1 4	. 0048	158. 4
9426. 533	0. 635	0. 0173	±0. 0005	159°.7	±0. 9	0. 0087	166°.5

TABLE 4

OBSERVATIONS OF β LYRAE WITH THE U FILTER

J. D. 2430000+	Phase	Observed Polarization P	m. e.	θ	m. e.	Intrinsic Polarization P	θ
8639 605	0. 780	$0^{m}.0117$	$\pm 0^{m}0005$	158°.3	± 1. 4	$0^{m}0039$	169°.5
8655. 573	. 016	. 0136	. 0006	163. 6	1 6	0066	176. 7
8658. 582	. 248	. 0135	. 0007	156 0	1 8	. 0054	160. 2
9301 794	986	. 0137	. 0012	151 6	2. 5	. 0055	149. 1
9305. 809	296	0120	. 0010	157 4	2 3	. 0041	165. 8
9307. 802	. 451	. 0040	. 0011	155. 0	8. 2	0043	61. 6
9313 819	. 916	. 0111	. 0005	156. 8	1 4	. 0031	166. 3
9314. 819	993	. 0112	. 0012	168 7	3. 0	. 0059	11 3
9318. 809	. 303	. 0098	. 0008	155. 2	2 2	0017	164 9
9319. 759	. 376	. 0099	. 0014	154. 9	4. 0	. 0018	162. 6
9323. 756	. 684	. 0124	. 0006	158. 1	1 4	. 0045	166 9
9326. 733	. 916	. 0095	. 0008	150 3	2. 5	. 0016	134 2
9327 708	. 991	. 0163	. 0013	154 0	2. 1	. 0081	154. 7
9331. 701	. 299	0136	. 0008	159. 5	1. 5	. 0058	168 4
9332. 686	. 376	. 0135	. 0008	157. 8	1. 7	. 0055	164. 7
9342. 688	. 149	. 0091	0007	155 8	2 2	. 0012	175 3
9346 785	. 466	. 0079	. 0016	157 5	5. 8	0012	29. 2
9400. 569	. 626	0141	. 0006	155 2	1. 1	. 0059	158 0
9401. 606	. 705	. 0137	. 0013	155. 0	2 7	0055	157. 6
9404. 580	. 936	. 0121	. 0010	157. 1	2. 3	. 0041	165. 1
9405 651	. 013	0121	. 0019	162 3	4 5	. 0050	177 9
9410 590	. 401	. 0099	. 0009	155. 5	2. 7	. 0018	165. 9
9418 586	. 020	. 0136	. 0010	147. 1	2. 0	. 0058	138 4
9423 571	. 405	. 0111	. 0009	159 0	2 2	. 0034	173 3
9424 569	. 482	0094	. 0008	158. 8	2 3	. 0021	3. 8
9425. 561	. 560	. 0112	. 0008	148. 5	2. 0	. 0034	136. 8
9425 573	561	0109	. 0010	150. 1	2. 6	0029	141. 0
9426. 548	0. 636	0. 0124	±0. 0004	157°.9	±0. 9	0. 0045	166°.7

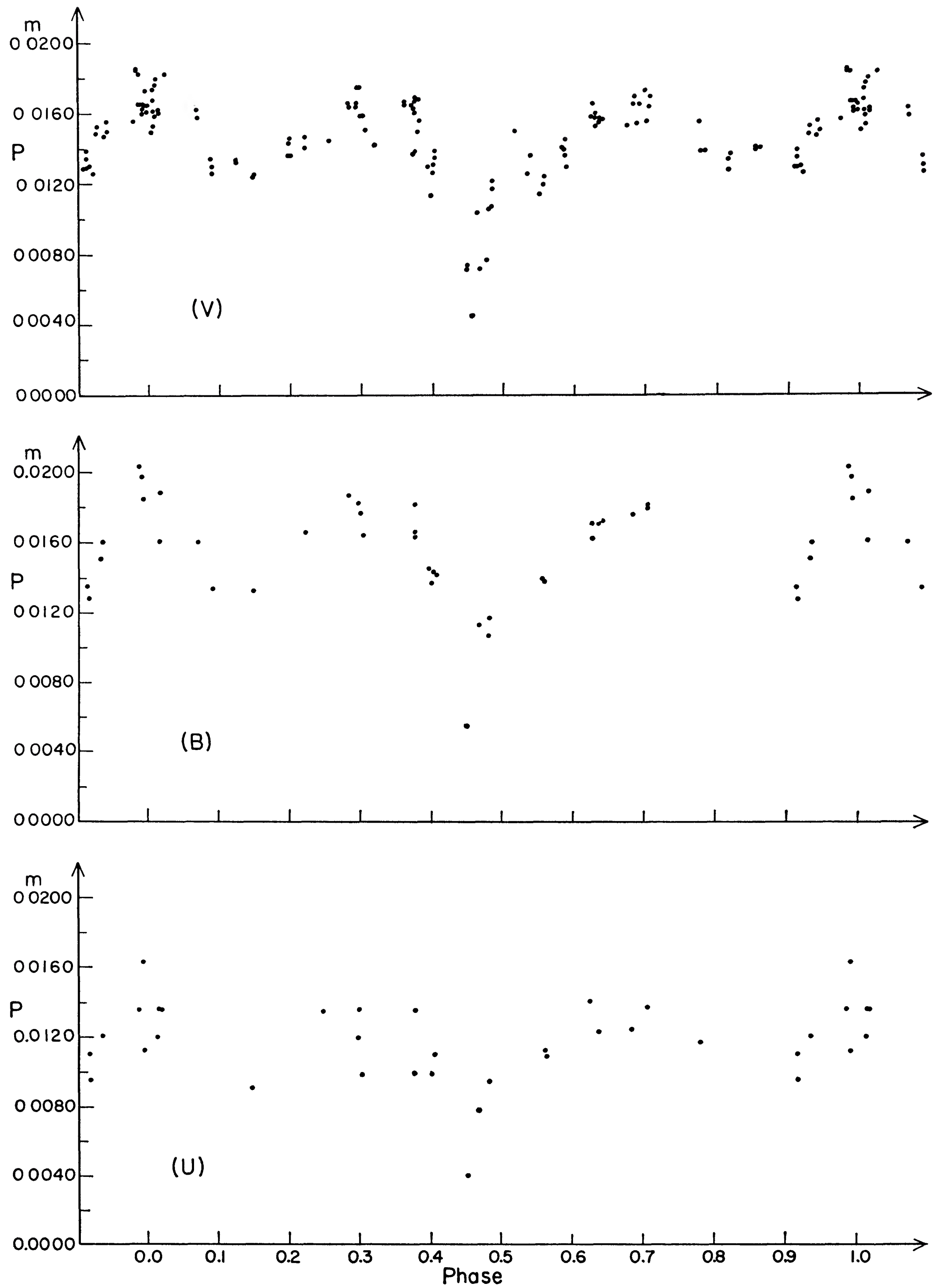

FIG. 1 —The observed polarization curves of β Lyrae. The position angle is not plotted because its change is negligible.

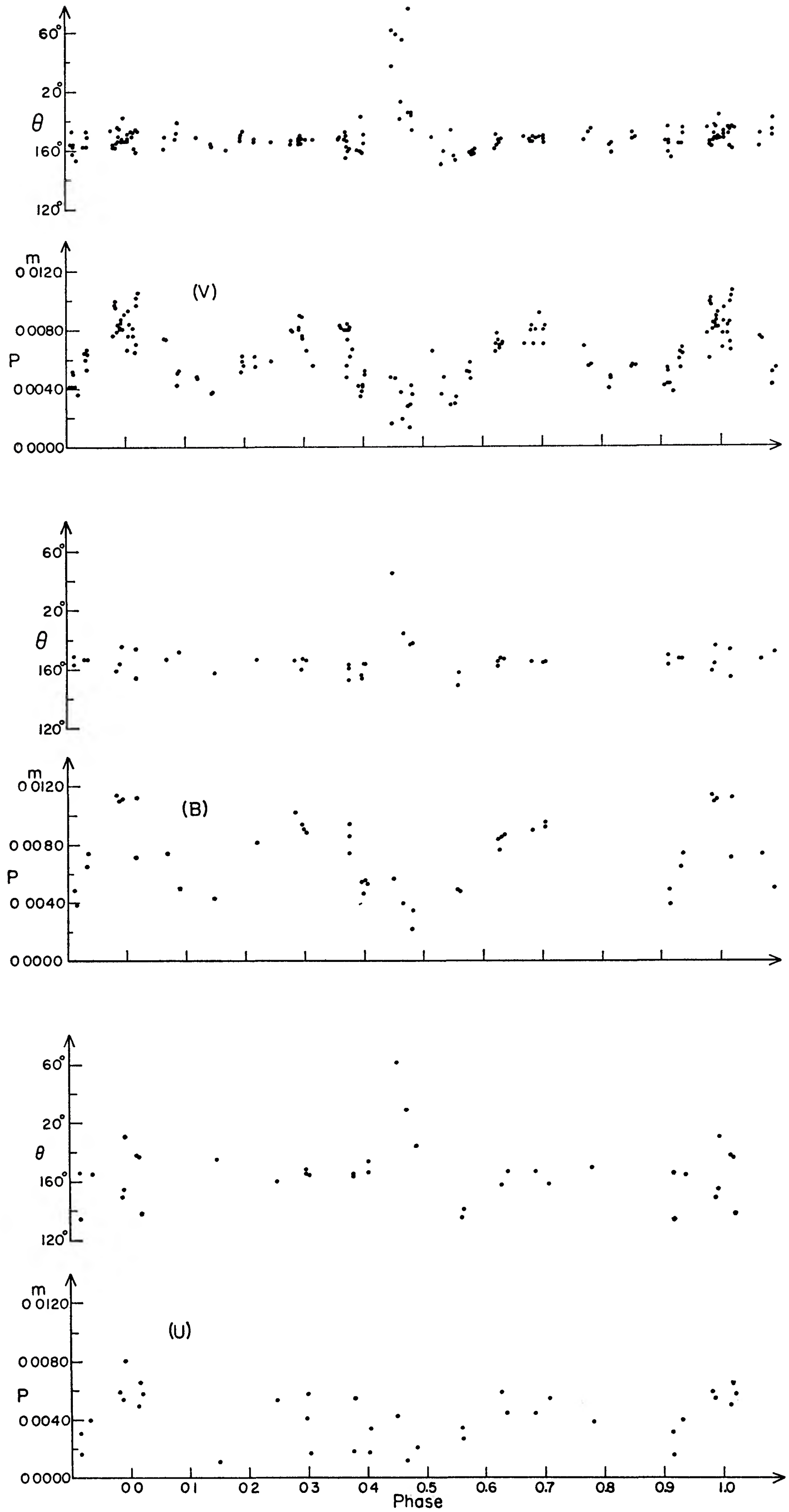

FIG. 2.—The intrinsic or true polarization curves for β Lyrae

scattered by the disklike secondary and in the common gaseous envelope of the system. The much smaller polarization in the ultraviolet light can be understood from the higher absorption in the gaseous envelopes of the light with wavelengths near and beyond the Balmer discontinuity. All polarization curves show a pronounced minimum at phase 0.5, when the scattering disk is eclipsed. Maxima of the intrinsic polarization are observed near the phases 0.3 and 0.7, where the average scattering angle for the visible part of the (probably slightly inclined) disk is optimal to produce polarization. Rucinski pointed out that the same result is obtained when scattering in the atmosphere of the more spherical central condensation of the secondary contributes to the polarized light, provided that the orbital plane is inclined by about $i = 75°$. The width and the shape of the minimum of the polarization curves at secondary eclipse indicate, however, that the outer parts of the disk of the secondary must contribute to the polarized light.

The intrinsic polarization maximum at primary eclipse can be explained by the decrease of the direct and, therefore, unpolarized component of the total light. We assume that almost all of the polarized light observed at this phase originates in the common gaseous envelope of the system that is responsible for the B4 absorption lines. This component of the polarized light probably changes only slightly with the phase (a small change with minima at phase 0.25 and 0.75 must take place because of the revolving shadow of the secondary). Little or no change of the position angle near the primary eclipse shows that electron scattering in the photosphere of the partial eclipsed primary does not contribute significantly to the observed polarized light.

It is interesting that the polarization curve of another eclipsing binary with a shell about one component but with no common gaseous envelope and with a much less deep primary minimum, V444 Cyg (Kron and Gordon 1950), seems not to show a third maximum of the polarization curve at primary eclipse (Hiltner and Mook 1966).

The absence of a detectable change in position angle of the intrinsic polarization of β Lyrae outside secondary eclipse indicates that the inclination of the orbital plane must be very nearly $i = 90°$. The change of the position angle during secondary eclipse shows however that i cannot be exactly 90°. For $i \neq 90°$ the partial eclipse of the scattering disk produces just the observed character of the variation of the position angle with different signs of the deviations before and after mideclipse. According to Huang's model, the hot region of the disk with the stream from the primary is partly eclipsed near phase 0.45. The electron density is probably higher in this region of the disk than in the part which is visible at phase 0.55. It seems likely, therefore, that the asymmetry of the change of the position angle is real. The large change of the position angle near phase 0.46 indicates, then, that the partial eclipsed secondary contributes more at this phase to the polarized light than the common envelope. However, it is possible but not likely that the difference in amplitudes before and after eclipse (phase 0.45 and 0.55) may be due to a systematic error in the derived value for the interstellar polarization.

VI. CONCLUSION

The preliminary qualitative analysis of the true polarization curves of β Lyrae probably provide the most direct confirmation of the model of the binary system, which has been suggested by Huang and investigated by Woolf. A quantitative analysis of our data may improve this model.

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