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INTRINSIC POLARIZATION IN XZ CEPHEI

Polarimetric observations of XZ Cephei were carried out during and after primary eclipses from October 1970 to October 1972 with the 80 cm telescope of the Haute Provence Observatory. Two different one-channel polarimeters were used:

- the first one, PI, described by Martel and Martel (1964) and later modified (Martel,1971) was operate up to June 1971;
- the second one, PII, operated in October 1972 only (see also Chevreton et al, 1977).

The filters used are approximately the standard U,B and V filters, their inverse effective wavelengths being respectively $1/\lambda = 2.74$, 2.33 and $1.87\ \mu m^{-1}$. The determination of the amount of linear polarization, P , and of the orientation of the electric vector, θ, is made according to the scheme described in Martel and Martel (1964) and adopted so as to take account of the light variation with time. Orbital phases were calculated according to the ephemeris

$$\text{Min I} = \text{J.D. } 2426033.52 + 5\overset{d}{.}09972155 \cdot E$$

given by Woodward (1943) and adopted by Kukarkin (1969).

The instrumental polarization parameters were determined using our polarimetric measurements on unpolarized standard stars. From Chevreton et al. (1977) there results a negligible instrumental polarization for any filter, using PII in October, 1972. About the interstellar polarization our measurements on the comparison stars used (BD +65°1774 and +65°1778) and the data available in the literature for other stars did not allow us to deduce the right parameters in the immediate vicinity of XZ Cephei, as it appears clearly from Table I.

Table I

The interstellar polarization and absorption in a large neighbourhood of XZ Cephei. The colour excess and distance modulus for BD +65°1774 were determined on the basis of our indices B-V=0.50 and U-B=-0.50 and the spectral type B2 II given by Hill and Lynas-Gray (1977).

Star name	l_{II}	b_{II}	$3E_{B-V}$	m-M	P%	θ°	Source
HD 213087	109	+6.4	1.95	9.3	0.97	23	a
					0.78	33	b
HD 213405	109.2	6.4	2.25	9.3	0.97	2	a
					0.60	9	b
HD 213481	109.5	7.4	2.13	10.9	1.95	27	d
(BD +65°1774)					2.38	31	e
					2.39	29	f
HD 213571	111.9	10.6	-	-	0.28	174	a
HD 213832	109.8	7.5	-	-	0.44	11	d
(BD +65°1778)					1.14	54	e
HD 215371	109.2	6.1	-	-	0.74	132	a
HD 216014	110.9	5.3	1.77	8.6	1.89	38	a
					1.61	58	b
HD 216228	111.1	6.2	0.01	2.4	0.01	108	c
(ι Cep)							
BD +63°1907	111.5	4.3	3.33	12.6	3.69	40	b

Sources: a)Hall, 1958 (λ_{eff}= 4500 Å); b) Hiltner, 1956 (λ_{eff}= 5400 Å); c) Behr, 1959 (λ_{eff}= 4600 Å); d), e) and f) This work (λ_{eff}= 3650, 4300 and 5350 Å).

Table II

The journal of observations

Hel.J.D. 2440000	Date	Orbital phase	$1/\lambda_{eff}$	(P±ΔP)%		(θ±Δθ)°		Δm
866.4545	06 X 70	0.0073	2.74	3.83±0.30		65.2±1.9		1.50
.4550		.0074		3.60	0.27	62.3	1.8	1.51
.5386		.0238		3.68	0.19	69.3	1.2	1.40
.5391		.0239		3.73	0.27	73.0	1.7	1.39
.5424		.0246		3.37	0.16	75.1	1.1	1.37
.5430		.0247		3.79	0.23	71.1	1.4	1.37
913.2958	22 XI 70	.1969		3.25	0.17	74.5	1.3	0.58
.2964		.1970		3.49	0.15	70.8	1.0	0.59
1131.5221	28 VI 71	.0098		4.65	0.19	70.0	1.1	1.53
861.3296	01 X 70	.0019	2.33	5.89	0.21	72.6	0.9	1.27
.3301		.0020		5.84	0.13	71.2	0.6	1.28
866.4444	06 X 70	.0054		4.29	0.10	73.1	0.6	1.29
.4449		.0055		4.15	0.13	72.6	0.8	1.29
.4491		.0063		4.92	0.24	70.1	1.2	1.29
.4496		.0064		4.80	0.23	70.5	1.2	1.28
.5193		.0201		4.01	0.21	84.0	1.3	1.22
.5199		.0202		3.80	0.46	82.8	3.0	1.21
.5245		.0210		4.98	0.21	69.5	1.1	1.20
912.3868	21 XI 70	.0186		3.91	0.27	71.0	1.8	1.31
.4059		.0224		4.89	0.51	71.5	2.6	1.27

Table II (cont.)

Hel.J.D. 2440000	Date	Orbital phase	$1/\lambda_{eff}$	$(P\pm\Delta P)$ %		$(\theta\pm\Delta\theta)^{\circ}$		Δm
913.3162	22 XI 70	0.2009	2.33	3.88±0.05		74.3±0.6		0.44
.3166		.2010		3.84	0.18	77.4	1.2	0.44
.3485		.2073		3.85	0.25	74.3	1.6	0.41
.3490		.2074		3.85	0.29	76.6	1.9	0.40
914.3601	23 XI 70	.4057		3.60	0.09	71.9	0.6	0.51
.3606		.4058		3.56	0.09	72.5	0.6	0.51
915.3310	24 XI 70	.5962		5.95	0.30	68.9	1.4	0.53
917.4054	26 XI 70	.0032		4.19	0.45	84.7	2.4	
1131.4799	28 VI 71	.0015		4.29	0.23	69.8	1.4	1.28
.4804		.0016		4.29	0.26	71.6	1.5	1.27
.5082		.0070		4.49	0.18	75.1	1.0	1.29
.5088		.0071		4.22	0.05	78.1	0.3	1.29
1600.4483		.0063		2.95	0.22	84.5	2.1	1.27
.4609		.0088		3.54	0.64	69.0	4.9	1.33
913.3382	22 XI 70	.2052	1.87	4.59	0.15	74.3	1.0	0.13
.3386		.2053		4.69	0.15	73.5	1.0	0.13
1131.4655	28 VI 71	.9987		4.29	0.04	75.2	0.2	0.97
.4660		.9988		4.40	0.04	74.6	0.3	0.97

Table II gives the journal of observations, in columns 1) the heliocentric Julian day, 2) the date, 3) the orbital phase φ of the system, 4) the effective wavenumber of the pass-band in inverse microns, 5) the intrinsic plus interstellar percentage of polarization P and the standard error ΔP, 6) the electric vector orientation θ and the standard error $\Delta\theta$, 7) the difference of magnitudes $\Delta m = m_* - m(BD\ +65^{\circ}1774)$*. Figure 1 presents for B filter the percentage P of polarization (intrinsic plus interstellar) and the orientation θ of the electric vector as functions of phase from the time of primary minimum to $\varphi=0.0205$. The vertical bars correspond to twice the standard errors. We represented by a horizontal dotted line the approximate mean value of P_B and θ_B outside eclipse for $\varphi=0.205$, i.e. $P_B=3.86$ % and $\theta_B = 76°$. These values could be reasonably considered as a measure of the interstellar polarization at XZ Cephei, under the condition that no part of this polarization effect is due to scattering in an external envelope (we shall examine this point later.).

In a general way, no correlation of P or θ with φ is present, due to the poor distribution of our measurements with time. In particular:

* Table II exhibits only some of the Δm values obtained from our polarimetric records.

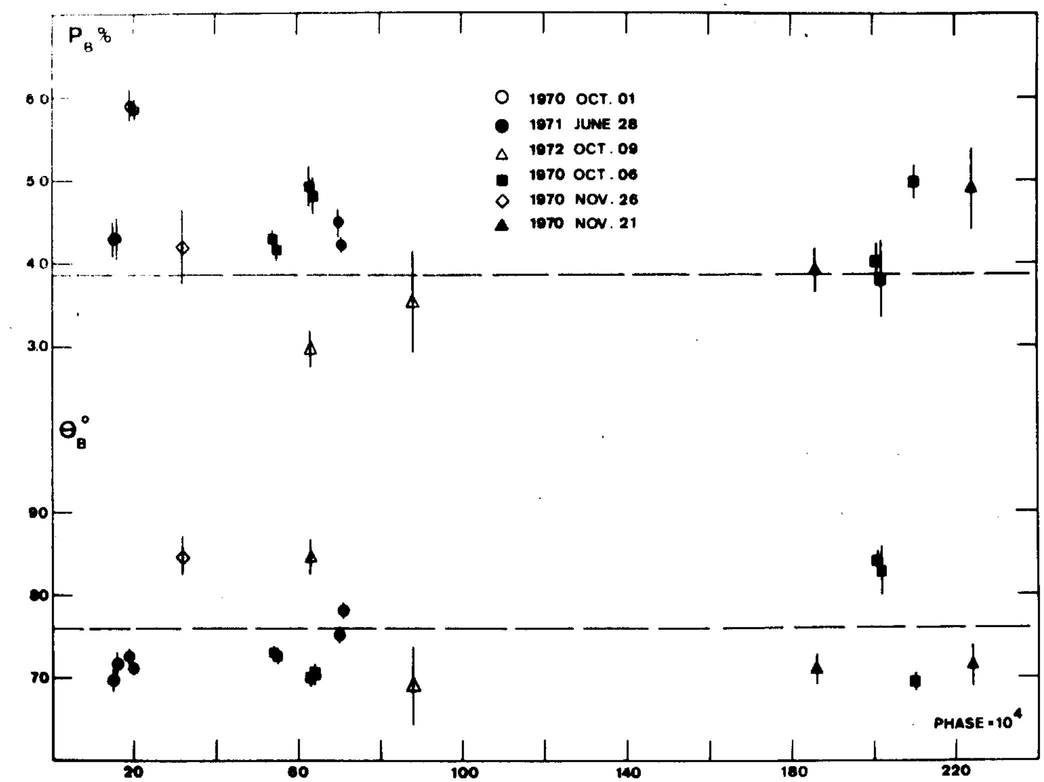

Figure 1. The polarization amount P_B and the orientation of the electric vector Θ_B ($1/\lambda=2.33\ \mu m^{-1}$) around and immediately after the primary minimum of XZ Cephei.

- From the comparison of P_B values on 1970 October 01, 1970 November 26 and 1971 June 28 at φ=0.0016, it follows that variations of P from cycle to cycle may exist, which could reveal the presence of non permanent circumstellar matter. We must notice that no corresponding variations of Θ occur in the above cases, except the peak value $\Theta_B = 84.^{\circ}7$ on 1970 November 26. Then, the enormous flow of matter necessary to produce an increase of 2% in the percentage of polarization should be highly concentrated in the equatorial plane so as to let Θ unchanged.
- On 1970 October 06, we notice the occurrence of large instantaneous variations of P_B and $\Theta_B$values, especially around φ=0.0205, and on the contrary the near constancy of P_U on the same date from φ=0.0073 to φ=0.0247. If real, these variations could originate only from very violent ejection of matter, inasmuch as the geometrical configuration remains the same. An identical conclusion holds on 1970 November 21.
- The peak values P_B=5.89% and 5.84% on 1970 October 01 and P_B=5.95% on 1970 November 24 are unhappily not related to simultaneous corresponding peak values in U or V colours. In U colour only one peak value is registrated, P_U=4.65% on 1971 June 28 and has to be compared to P_U=3.83% and 3.60% on 1970 October 06 at φ=0.0073.
- Finally, it is interesting to note that during the orbital cycle from 1970 November 21 to 1970 November 26, two very different values of P_B are recorded at φ=0.4 and φ=0.6, i.e. for two identical geometrical configurations of the system (under the condition of a circular orbit) apart a reflection in a plane through the line of sight and perpendicular to the orbital plane.

Very few data are available about the physical parameters of the system. Only one spectrum is known: O 9.5 from Roman (1956). The O character of the composite spectrum was born out owing to the U-B and B-V indices deduced from our polarimetric records for a number of values of φ representative of the entire orbital period. All the corresponding points in the $[(B-V)_o,(U-B)_o]$ diagram are scattered exactly around the reddening path for O stars (slope 0.72) in a circle of radius 0.06 centered on B-V =+0.80 and U-B=-0.33 (Let us mention that for BD +65°1774 our value B-V=+0.50 is in good agreement with the value B-V=+0.55 given by

Hill and Lynas-Gray (1977)). There results a high value of reddening A_V=3.3 magnitudes which would give a distance r=280 pc, on the basis of the absolute magnitudes M_1=-1.2 and M_2=-1.1 adopted by Dworak (1975). Indeed, this value of r is in serious disagreement with the photometric parallax π''= 0.0011±0.0005 calculated by Dworak with the above values for M_1 and M_2.

Instead, we shall adopt M = -4.5 which is probably not so far from the true value for a system consisting of an O 9.5 primary component and a somewhat cooler secondary component. This would give a distance r=920 pc: in this case too, the major part of the absorption would be of circumstellar origin, as shown from inspection of the (r,E_y) correspondence of Fitzgerald (1968).

From our polarimetric measurements, we suspected some variations of the instrinsic polarization of XZ Cephei. This preliminary study has to be supported by new extensive polarimetric and spectroscopic investigations.

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