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POLARIMETRIC OBSERVATIONS OF U CEPHEI DURING THE PRIMARY ECLIPSE

Polarimetric observations of U Cephei were made during six primary eclipses from Oct. 1972 to Oct. 1975. The observations were carried out using the polarimeter and reduction methods described by Piirola (1973, 1975). The polarimeter was attached to the 60 cm Ritchey-Chrétien telescope of the University of Helsinki. A standard B-filter and an integration time of 20 s at each of eight position angles of the instrument were used.

The observed degree of linear polarization P and position angle Θ in equatorial coordinates are plotted as a function of phase in Figs. 1 and 2. Each point represents a single observation. The error bars correspond to internal standard errors, computed from measurements made at the eight position angles of the polarimeter. Internal errors are mainly due to photon noise. The phases were calculated according to the ephemeris

$$\text{Min.I: J.D.} = 2441938.8476 + 2^{d}.4930822 \cdot E,$$

derived from observations of Baldwin (Scarfe et al. 1973).

From Fig. 1 we can see that on 1975 Sept. 08 the degree of polarization P increased during the eclipse and reached a maximum near third contact. Also the position angle Θ changed near second contact. On 1972 Dec. 27 some increase of polarization occurred both near second and third contact and the position angle varied during the total eclipse. On 1973 Feb. 10 changes were small both in the degree and the position angle of polarization.

From Fig. 2 we can see that on 1975 Sept. 18 and Oct. 03 the degree of polarization reached two maxima, one near second and the other near third contact. Changes in the position angle were similar to those on 1975 Sept. 08 (Fig. 1).

In Fig. 3 the positions of the primary component, with respect to the secondary component at second and third contact, are presented. The geometrical dimensions are taken from Hall and Walter (1974a).

The increase of polarization and the changes in position angle near second contact can be explained by circumstellar matter surrounding the primary. The outer radius of the circumstellar matter can be estimated from the decrease of polarization after second contact. As also the position angle changes, the matter is not strictly confined to the orbital plane. The increase of polarization near third contact can be explained by circumstellar matter in the vicinity of the preceding hemisphere of the primary component, appearing soon after mid-eclipse and thus having greater extension than that at the trailing side of the primary component. This is what is also predicted from the theoretical investigations of Prendergast and Taam (1974), and what also has been suggested as an explanation of increasing intensity during the total eclipse, found from photometric observations (see e.g. Hall and Walter 1974a, Walter 1975).

The change in position angle near third contact should be opposite to that observed near second contact (see Fig. 3). In Fig. 2 we can see that such a change really exists. However, the change is smaller, and almost absent in Fig. 1. This indicates that the matter in the vicinity of the preceding hemisphere of the primary component, having greater extension, is also more strongly confined to the orbital plane and the position angle of the polarization of the light scattered in the matter remains approximately perpendicular to the orbital plane. Consequently, the position angle of polarization observed after third contact ($\theta \approx 95^{\circ}$) gives the direction of the orbital plane projected on the celestial sphere ($\theta - 90^{\circ} \approx 5^{\circ}$, Fig.3).

Since the position angle remains close to 95° also outside the eclipses, most of the polarization seems to be intrinsic. The minimum value of polarization, $P \approx 0.10$ %, observed after first contact when the matter at the preceding hemisphere of the primary is eclipsed, shows that interstellar polarization should be less than 0.10 %. If the position angle of interstellar polarization, $\theta_{int} \neq 95^{\circ}$, the upper limit is still smaller.

As the increase of polarization is not similar during each eclipse and sometimes very small (Fig.1), the circumstellar matter is not permanent. This is indicated also by the polarimetric observations of Coyne, made in September 1973, which did not show increase of polarization during the primary eclipse (Coyne 1974, Batten 1974).

One interesting feature seen in Figs. 1 and 2 is that on 1975 Sept. 08 the increase of polarization near second contact was small,

but on 1975 Sept. 18 and Oct. 03 as large as near third contact. Thus the amount of matter in the vicinity of the trailing hemisphere of the primary component was about three times larger on 1975 Sept.18 than 10 days earlier. This would indicate changes in the mass transfer from the secondary component, which is filling its Roche lobe, to the primary, i.e. changes in the stream from the inner Lagrangian point to the trailing side of the primary. Further, polarization near third contact was on 1975 Oct. 03 larger than on 1975 Sept. 18. Accordingly, more matter was accumulated above the preceding side of the primary component, when part of the stream circulated around the primary component.

A more detailed description of the observations and interpretation of the results will be given elsewhere.

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References

Batten, A.H. 1974, Publ. Dominion Astrophys. Obs. Victoria 14,Nr.10
Coyne, G.V. 1974, Ricerche Astronomiche 8, 475
Hall, D.S., Walter, K. 1974a, Astron.and Astrophys. 37, 263
Hall, D.S., Walter, K. 1974b, Astron.and Astrophys.Suppl.19, 337
Piirola, V. 1973, Astron and Astrophys. 27, 383
Piirola, V. 1975, Ann.Acad.Sci.Fennicae, A VI, Nr. 418
Prendergast, K.H., Taam, R.E. 1974, Astrophys.J. 189, 125
Scarfe, C.D. et al. 1973, I.B.V.S. Nr. 844
Walter, K. 1975, Astron.and Astrophys. 42, 135

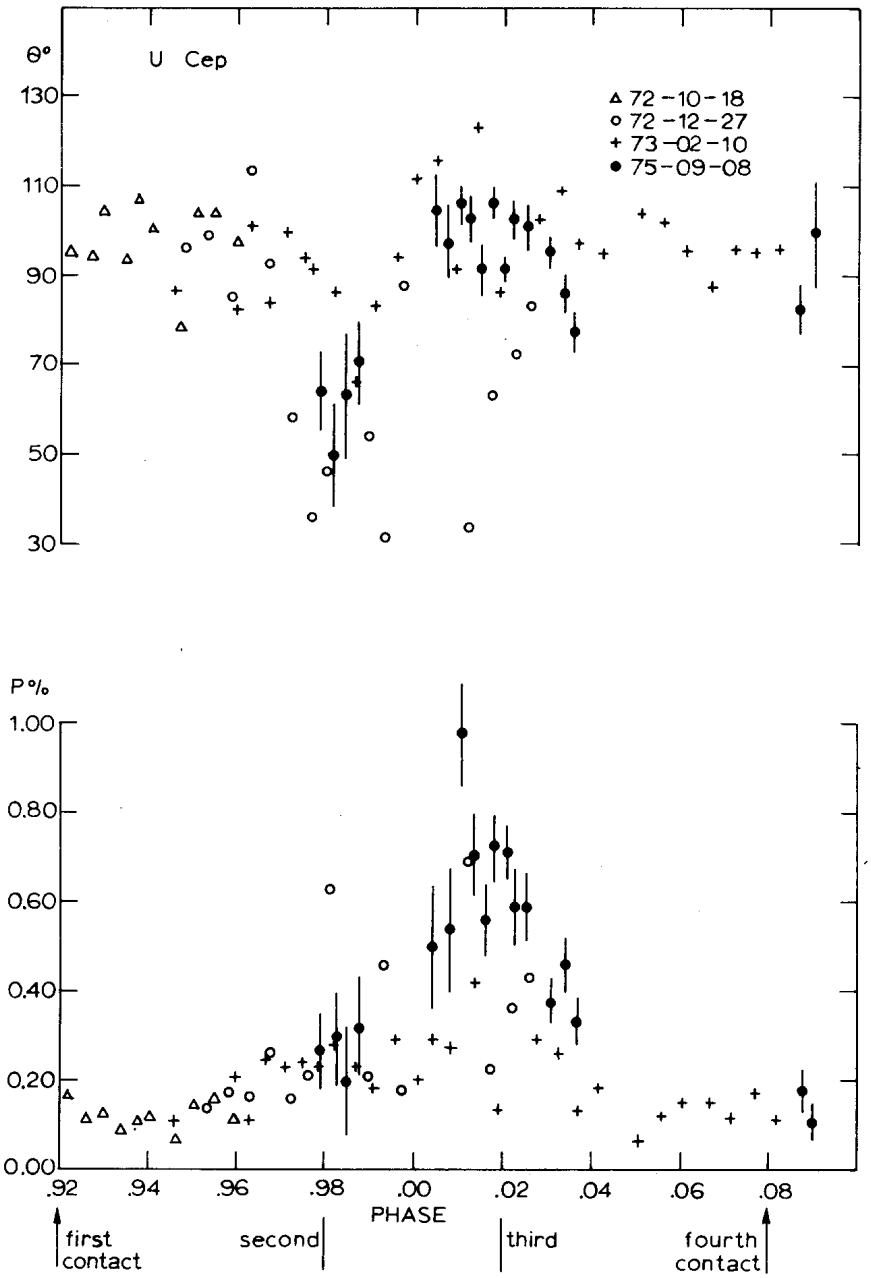

Fig.1. Polarimetric observations of U Cep during four primary eclipses from October 1972 to September 1975, plotted as a function of phase.

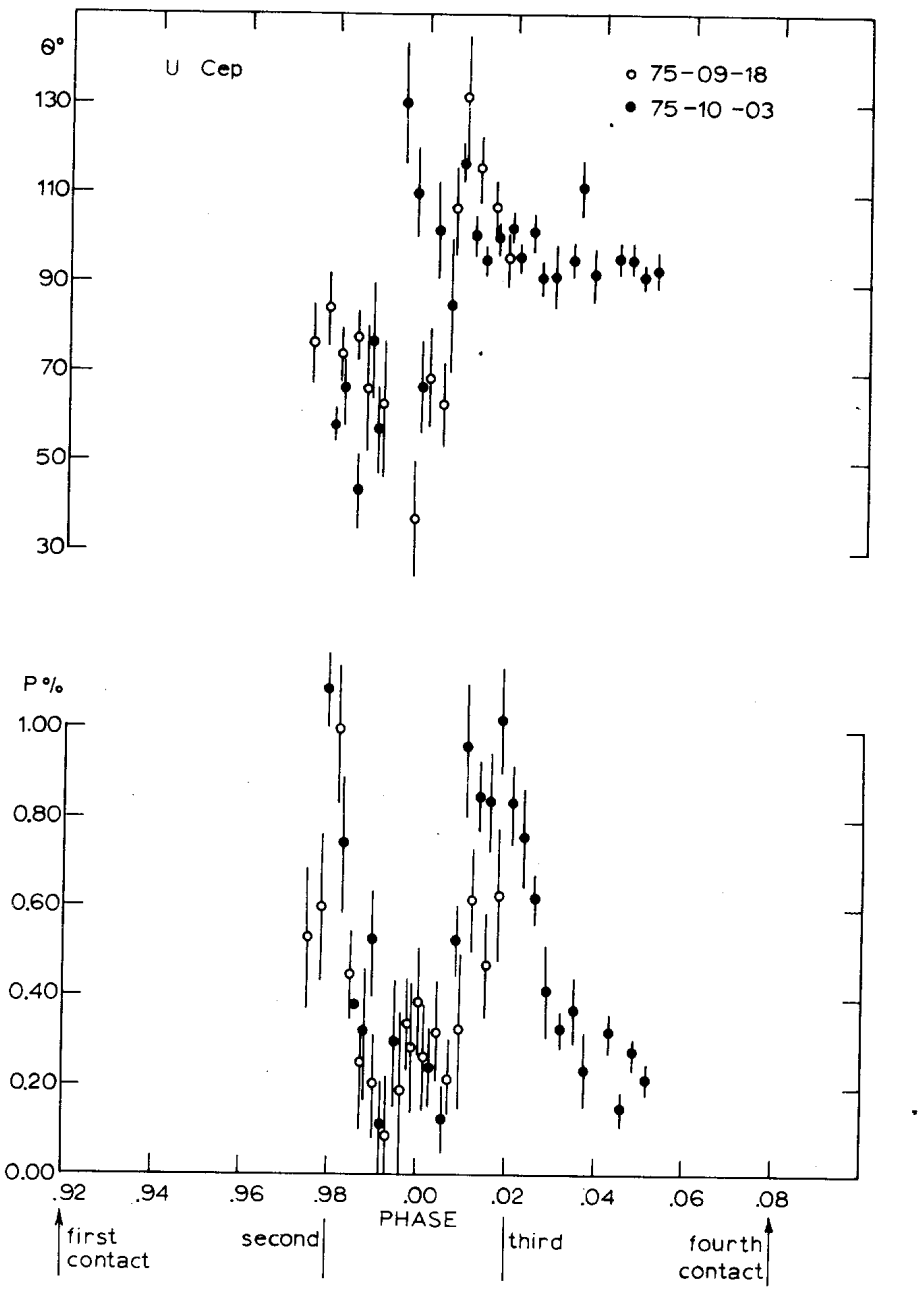

Fig.2. Polarimetric observations of U Cep during two primary eclipses in September and October 1975, plotted as a function of phase.

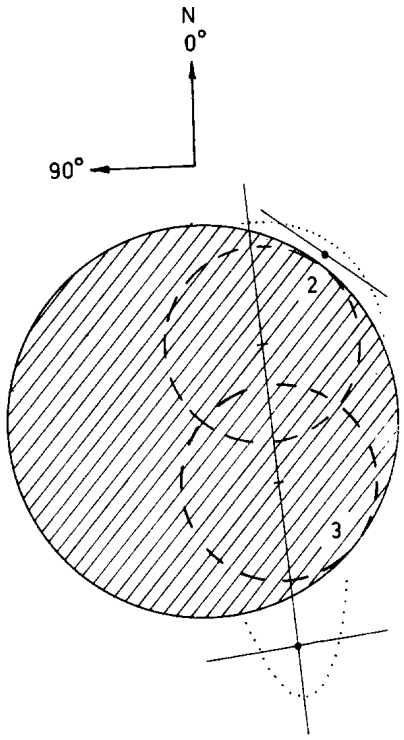

Fig.3. The position of the primary (smaller but much brighter) component and the circumstellar matter, with respect to the secondary component, at second and third contact during the primary eclipse. The approximate position angle of the polarization, produced by light from the primary scattered in the circumstellar matter, is given by the bars. Near third contact and outside the eclipses the direction of polarization is approximately perpendicular to the orbital plane, thus giving the direction of the orbital plane projected on celestial sphere.