POLARIZATION OF 6 CM RADIATION FROM THE CRAB NEBULA*

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Linear polarization measurements at 6 cm wavelength with the 210-ft Parkes radio telescope have shown that the polarization of the Crab nebula is concentrated in an area under 2′ in angular extent centred $0'{\cdot}5 \pm 0'{\cdot}2$ to the west and $1'{\cdot}1 \pm 0'{\cdot}2$ to the south of the centre of the total emission.

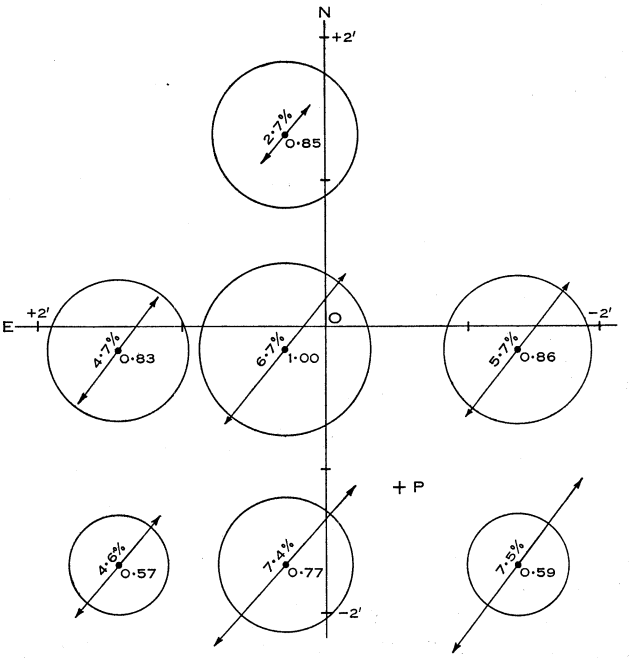

Fig. 1.—Variation of 6 cm intensity and polarization across the Crab nebula. At each point measured the total intensity is given as a fraction of the central intensity and is proportional to the diameter of the surrounding circle, while the arrows show the direction and degree of polarization expressed as a percentage of the central intensity. The total intensity is centred at O and the polarized emission at point P.

The results of the observations‡ made in October 1963 are shown in Figure 1. For each point observed the total intensity is expressed as a fraction of the central intensity and is indicated by the diameter of the surrounding circle; the arrows show the direction and degree of polarization expressed as a percentage of the central intensity.

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‡ The experimental method and the procedure for evaluating spurious effects will be discussed in a forthcoming paper by Davies and Gardner.

Within the accuracy of the measurements the position angle of the polarization is the same at all points, namely $141 \pm 3°$. It is apparent that the centre of the polarized emission, P, is displaced from the centre of total emission, O. With centre P, determined on the assumption of circular symmetry, the angular distribution of polarization is not significantly broader than the aerial beam. (The best estimate of

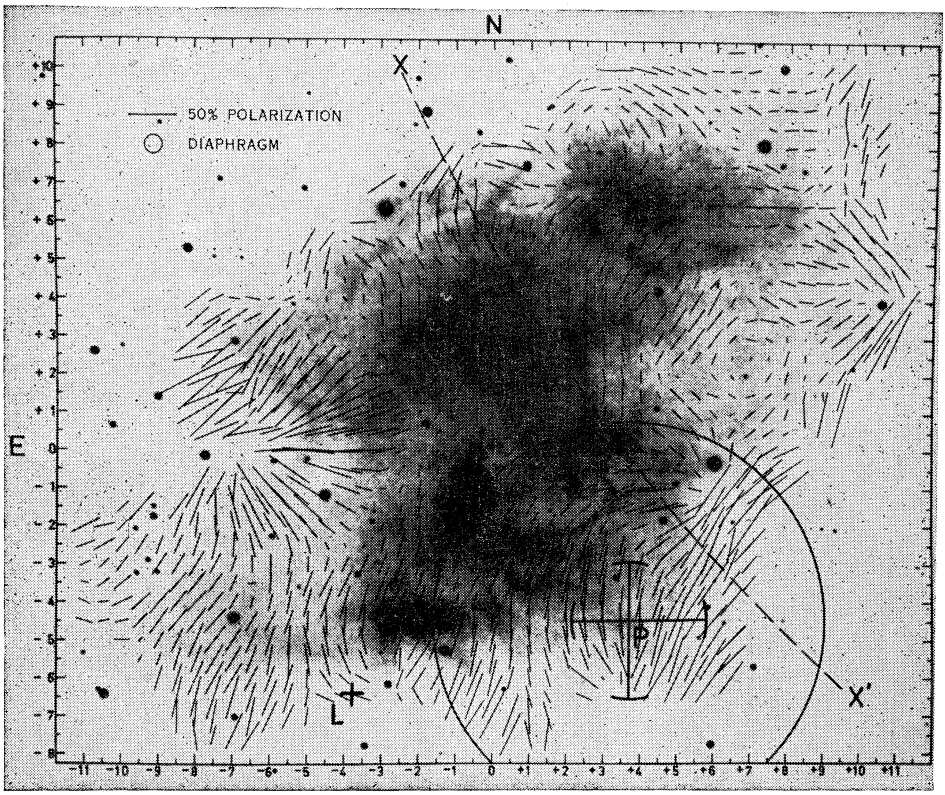

Fig. 2.—The centre P of the 6 cm polarization distribution and a circle showing the approximate extent of the polarization superposed on the distribution of optical polarization given by Woltjer (1957). The small diameter 26 Mc/s source is shown as L; the X-ray source lies along the line X–X′. The origin of Woltjer's diagram is the south-west component of the central double star, R.A. $05^h\ 31^m\ 31^s{\cdot}5$, dec. $+21°\ 58'\ 55''$ (1950). Scale: 1′ arc = 5·4 units.

polarization half-width is 4′·2 compared to the beamwidth of 4′·1, while the observed total intensity half-width of Taurus A is slightly over 5′·0 in both coordinates.) The actual percentage polarizations of the small-diameter source must be high (probably over 20%), since the apparent percentage polarization, shown by the ratio of the arrow length to the circle diameter, increases progressively along the radius from O to P, reaching 12·7% (= 7·5/0·59) at the furthermost point measured, compared with 6·7% near O. Should the polarization source be extended to the south-west, and observations further out are required to settle this, the apparent percentage polarization would be even higher in the extension.

The existence of a polarization concentration is in agreement with the observations at 3 cm at Pulkovo by Soboleva, Prozorov, and Pariiskii (1963) and at 10 cm at Caltech by Morris, Radhakrishnan, and Seielstad (1964). However, the result of the former workers was that the polarized emission was east of the total-intensity peak observed with a fan-beam antenna, and that the position angle varied markedly across the source, both of which conflict with our results; but Pariiskii (personal communication) has indicated that more recent observations at Pulkovo are consistent with those reported here. The result of Morris, Radhakrishnan, and Seielstad was that the polarization was uniform in direction and confined to an area about 1′·9 in diameter in which the percentage polarization was 8–10%. They did not measure a position.

In Figure 2 the position of the polarization centre P is shown on Woltjer's (1957) distribution of optical polarization. The radio-optical superposition is made on the basis of coincidence between the centres of radio and optical emission. Lunar occultations observed at 408 Mc/s by Seeger and Westerhout (1957), and more recently at 400 and 1400 Mc/s by Davies, Hazard, Gardner, and Mackey (unpublished data), show that the two agree to within 0′·2. From the optical distribution in Figure 2 there is no reason to expect that the polarized emission would be displaced to one side of the nebula, although in the region around P the optical percentage polarization is high and fairly uniform in direction. The average optical position angle in this area is 160–170° east of north compared with the radio intrinsic polarization angle of 150–155° (141° corrected for a Faraday rotation of -27 rad/m^2; see Gardner and Whiteoak 1963).

Figure 2 also shows the position L of a small-diameter (20″ arc) source with a steep spectral index found by Andrews, Branson, and Wills (1964) at 26 Mc/s. It does not appear to be related to the polarized source. Recently Bowyer *et al.* (1964) have detected an X-ray source about 1′ in diameter which is located along the line X–X′ in Figure 2 (their 230 sec line). This line X–X′ is displaced from P by a little more than the estimated position errors. The future determination of the location of the X-ray source along X–X′ will show whether there is any possiblity of a relationship between the two phenomena.

It is difficult to explain the rapid change in the prominence of the polarization feature with increasing radio wavelength by Faraday rotation (the polarization drops from 15–20% at 6 cm to below 3% at 20 cm in the occultation observations of Davies *et al.*), in view of the small overall rotation measure which would change the position angle by only 60° between 6 and 20 cm. In addition it is necessary to explain why some regions, highly polarized at optical wavelengths, are not polarized at 6 cm. It is evident that the radiation processes in the Crab nebula are not fully understood. As far as the radio measurements are concerned there is a definite need for higher resolution measurement of polarization over a range of frequencies.

References

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