LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Polarization of the Radio Pulses from the Crab Nebula Pulsar

We have undertaken a systematic investigation of the polarization of radio pulses from a number of pulsars, using a polarimeter feed in the Mark I radio telescope at 408 MHz. The results for the Crab Nebula pulsar, NP 0532, are of special interest, because they may be compared with the optical polarization recently measured by Wampler *et al.*[1]. We therefore now present a preliminary analysis for the main radio pulse, both in the form of an integration over many pulses and for individual pulses recorded photographically.

Our apparatus records independently the four Stokes parameters, presenting them either on a 4-channel oscilloscope, which displays individual pulses, or as integrated pulse profiles, giving the average over some thousands of pulses received over a period of several minutes. The pulsar NP 0532 is notoriously variable in that it occasionally produces an individual pulse very much larger than the average, so that about 1 in 10^4 pulses is photographable on the oscilloscope. We therefore arranged to trigger the oscilloscope only for large pulses; these were detected in a separate radio receiver tuned 2 MHz higher in frequency, so that the pulse arrived 12 ms earlier in the triggering channel, due to the interstellar dispersion in pulse arrival time.

Tracings of some of these photographs are shown in Fig. 1. All were recorded in the space of 10 min. The receiver bandwidth was 330 kHz (to 3 dB points), and the time constant of the detector was 0·5 ms. The pulses with apparent half-widths about 3·5 ms are therefore somewhat lengthened by dispersion in the receiver bandwidth, amounting to 2 ms. The polarization is predominantly linear, and totals about 70 per cent. It may be seen that the position angle of the plane of polarization of the largest pulse differs by more than 60° from those of the smaller pulses. With the present time resolution there is no conclusive evidence of fine structure in these pulses.

The shape of the integrated pulse profiles is very similar to that of the individual pulses, and also shows high polarization. At the peak of the pulse the ratio

$$\frac{(Q^2+U^2)^{\frac{1}{2}}}{I}=0{\cdot}65\pm0{\cdot}15$$

The plane of polarization does not rotate by more than 20° during the central 3 ms of the pulse, and does not change between successive 4-min integrations. The interpulse is less strongly polarized.

The high degree of polarization of the main pulse shows that the plane polarization does not contain much fine structure with time scale less than the present resolution, and further that the position angle variation from pulse to pulse is usually small. Other measurements made at 240 MHz with a time resolution of 3 ms show the same high degree of linear polarization.

These results are in sharp contrast to the optical measurements, which show only 10–15 per cent polarization, with a plane swinging through 120° during the centre 2 ms of the pulse. Wampler *et al.*[1] show that the optical results fit well with a simple geometrical model of the pulsar, in which the plane of polarization is determined by the orientation of two axes, a rotation axis and another related to the magnetic field. If the main radio and optical pulses are emitted simultaneously, then the model must evidently be revised. Observations at Arecibo, however (F. Drake, personal communication), have shown that the integrated profile of radio pulses observed at 408 MHz and lower frequencies shows a broad precursor pulse a few milliseconds before the sharp feature corresponding to the optical pulse. If our recordings refer to the precursor, it should be possible to describe the polarization angle as a continuous function through a considerable part of the pulsar cycle. We would then surmise that the sharp pulse and the precursor originate in different but adjacent regions.

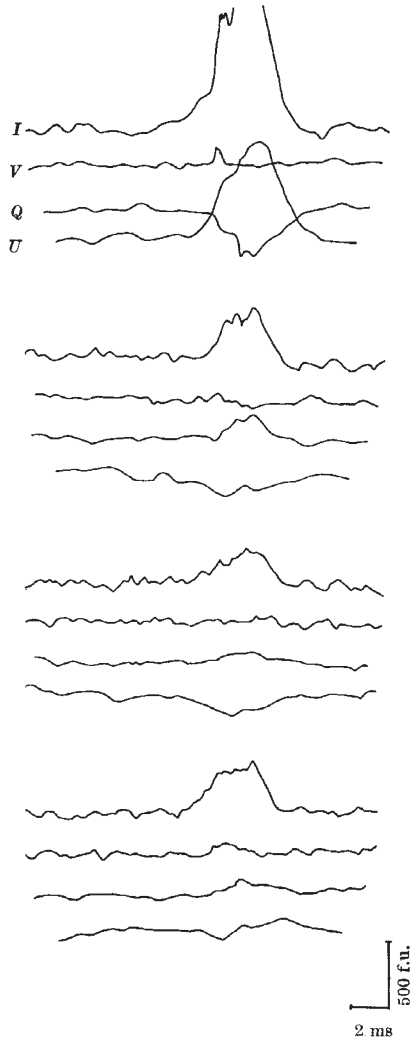

Fig. 1. Stokes parameters I, V, Q and U of four individual pulses from NP 0532.

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[1] Wampler, E. J., Scargle, J. D., and Miller, J. S., *Astrophys. J. Lett.*, 157, L1 (1969).