Absence of Average Polarization at 111·5 MHz in Pulsar NP 0532

THE average polarization properties of NP 0532 have been measured at about 400 MHz by us[1], by Manchester (private communication) and by Schonhardt[2]. Strong linear polarization is present in the precursor while the other pulse components are only weakly linearly polarized and the position angle is independent of pulse phase. The polarization properties of strong single pulses have been measured at high frequency by ourselves[3,4] and at lower frequencies by Staelin and Sutton[5], who have shown that large linear polarization does not occur in strong pulses. We have now measured the four Stokes parameters of the average pulse at 111·5 MHz.

The only difference in technique from our previous work was the use of a feed which yielded two orthogonal linear polarizations. The details of obtaining the Stokes parameters then differ slightly from our previous experiment in which two circular polarizations were provided by the feed. The four channels produced at baseband were passed through identical filters having a double-sideband width (to the 3 db points) of 5 kHz and were then digitized and recorded synchronously with the pulsar at 100 μs intervals throughout the entire pulsar period. We assumed the average intensity from the pulsar and the Crab Nebula itself to be unpolarized and used this as a calibration to eliminate instrumental polarization; thus the experiment was insensitive to time-independent linear polarization in the pulsar.

We carried out the observations for 3 h on both January 7 and January 11, 1970. The critical frequency of the ionosphere was measured at approximately 15 min intervals during the observations, using the ionosonde at Arecibo Observatory, and ionospheric Faraday rotation was calculated approximately using ionospheric density profiles supplied by G. Nelson.

Having accounted for rotation of the feed during tracking, we found that ionospheric Faraday rotation had rotated the position angle of linear polarization through about 140 degrees during each run. Each day's data were reduced in a series of short blocks accounting properly for Faraday rotation, and additionally in a series of short blocks in which the effects of Faraday rotation were ignored. In no case did we find appreciable linear or circular polarization. The present observations thus imply

$$P = \frac{\text{Peak-to-peak variation in } Q, U, \text{ or } V}{\text{Peak-to-peak variation in I}} \leq 0{\cdot}2 \quad (1)$$

The precursor pulse component at 430 MHz is essentially 100 per cent linearly polarized and is responsible for about 0·4 of the integrated (continuum equivalent) flux density. If the relative energies and polarization properties of the emitted pulse are similar at 111·5 MHz then the broadened observed pulse should exhibit more than 50 per cent linear polarization in the vicinity of the main pulse. Several explanations for the observed lack of polarization are plausible: the precursor may have become weak relative to the other pulse components at 111·5 MHz; it may not be strongly polarized on emission at the pulsar; or a strongly polarized precursor may have become depolarized in the medium in transit to Earth.

None of the above possibilities are subject to direct confirmation; however, Rankin *et al.*[6] have measured the integrated flux density of the precursor relative to the main pulse and found that the ratio is roughly independent of frequency in the interval 430 to 196·5 MHz. They argue that although the main pulse and precursor cannot be resolved at 111·5 MHz it is unlikely that their relative flux changes greatly in the octave between 196·5 and 111·5 MHz. In this case we may ask whether the depolarization is intrinsic to the source or occurs in the medium between Earth and the pulsar. Clearly, a strongly polarized precursor is severely broadened by scattering in the interstellar medium[6]; the scattering will not in itself change the fraction of linear polarization or its sense. But scattering introduces the possibility that differential Faraday rotation may occur on the various paths of propagation. We expect the scattering angle to be about 6×10^{-7} radians on the basis of the current knowledge of interstellar scintillation[6] and we believe it is unlikely that depolarization due to differential Faraday rotation occurs over such a small angular extent. (An observational indication of the importance of differential Faraday rotation at these low frequencies is provided by polarization measurements on quasars, which are observed to be linearly polarized at high frequency.)

Thus it seems most probable that either the pulsar's 111·5 MHz radiation is depolarized in the Crab Nebula, or in the immediate vicinity of the pulsar, or that the pulsar's radiation at low frequency is not strongly polarized on emission. A need for further polarization measurements of the Crab Nebula pulsar at intermediate frequencies is clearly implied.

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Battery Effect in Neutron Stars

RECENTLY there has been interest in the problem of intense magnetic fields in gravitationally collapsed bodies[1,2]; in particular the radio emission from neutron stars (pulsars) suggests strong magnetic fields of the order of 10^{12} G (refs. 1, 3 and 4). The battery effect for nonuniformly rotating early main sequence stars has been considered recently[5,6], but we will show in this communication that there is a possible battery effect in neutron stars which has a different physical cause.

Let us consider a rotating star which is composed only of neutrons, protons and electrons, and assume that they are completely degenerate. I have considered such a model of the neutron star and shown that the magnitude of the stationary magnetic field cannot be more than a few gauss. Here I shall show that there is a possibility that a non-stationary magnetic field of the order of 10^{12}G can be generated.

The effect of gravity will be considered using the post-Newtonian approximation. We assume that $\varphi/c^2 \ll 1$, so that only first order corrections in φ/c^2 to the Newtonian theory will be included in the basic equations of this problem. Then the space–time metric will be[8]

$$ds^2 = g_{ik}\, dx^i\, dx^k \quad (1)$$

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