LETTERS TO THE EDITOR

ASTRONOMY

Polarization of Galactic Radio Emission at λ 1·25 m

SYNCHROTRON radiation from the Milky Way at radio wavelengths is linearly polarized if the magnetic field in the emitting region is in the same direction throughout the line of sight, and if the Faraday rotation is small within the emitting region. Observations at λ0·21 m show polarization up to 25 per cent in a direction somewhat inclined from the perpendicular to the spiral arm; at λ0·73 m the percentage polarization is less, and the polarized area is also less, indicating that Faraday rotation is becoming important. The polarization at longer wavelengths has so far remained unknown, in spite of several attempts to measure it[1-4].

The reduction of polarization at longer wavelengths might be attributed to Faraday rotation within a region of highly organized field, generally running along the spiral arm. Bingham and Shakeshaft[5] show that a diverging field fits the data well, but their model, along with any other involving a smooth field, does not easily fit the data in a region of maximum polarization near $l=135°$, $b=5°$, where the high degree of polarization indicates that the line of sight traverses a large region of constant Faraday depth[5], that is inside which the rotation is zero. Here the polarization falls with increasing wavelength without a corresponding rotation of the plane of polarization, and it is therefore necessary to postulate in addition that there is a less regular component of the variation of Faraday depth through the emitting region. This "random" component must comprise reversals of the line-of-sight component of the magnetic field.

Irregularities in Faraday depth would also show up as irregularities in the angular distribution of polarization, possibly on a small angular scale which would give an average polarization near zero over a telescope beamwidth of a few degrees. Such irregularities have been found in a recent survey using the Mark I 250 ft. telescope at λ0·73 m, with a beamwidth of 45′ arc. (These observations will be reported separately.)

Further confirmation of this physical picture has now been sought by using the telescope as a polarimeter at λ1·25 m, to survey the area $02h < \alpha < 05h$, $55° < \delta < 65°$, which contains the highly polarized region at $l=135°$, $b=5°$. At the longer wavelength the internal depolarization of irregularities dispersed through the emitting region would be expected to remove most of the polarization; a further reduction was expected because the irregularities would not be completely resolved by the beamwidth of 75′ arc, so that the observed polarization would be appreciably less than the actual polarization brightness temperature.

In this survey, the polarimeter only detected the difference between vertical and horizontally polarized components. The sidelobes of the aerial feed, which was a simple crossed dipole system, interacted with the large scale structure of unpolarized emission to give a baseline uncertain to about 3° K near the galactic plane, although small-scale polarized structure could be detected with certainty down to a polarization brightness temperature T_{pb} of about 2° K.

Most of the region near $l=135°$, $b=5°$, now seems to be unexpectedly highly polarized at λ1·25 m. Regions where T_{pb} exceeded 3° K are shown in Fig. 1.

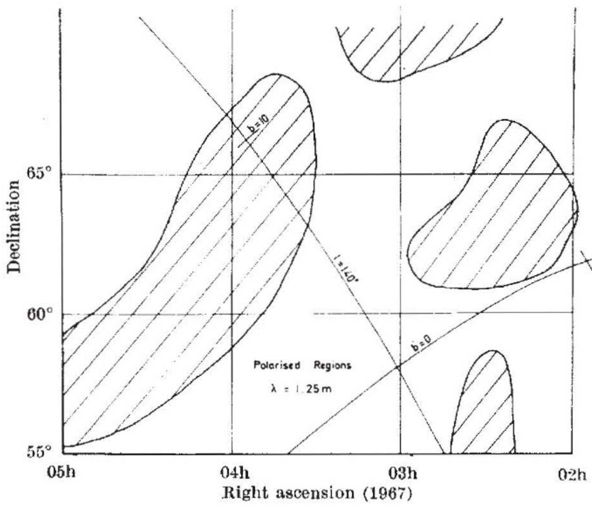

Fig. 1.

Inside these regions, the polarization varied rapidly with angle, often with structure unresolved by the telescope beam. Nevertheless, the recorded values of T_{pb} often exceeded 8° K, while at λ0·73 m the corresponding value of T_{pb} is typically only 4° K. Over all other regions of sky covered by this brief experiment at λ1·25 m, including a large region covering the North Galactic Spur, T_{pb} was found to be less than 2° K.

The high degree of polarization remaining at λ1·25 m, amounting to at least 5 per cent as compared with a theoretical maximum of 70 per cent in a perfectly aligned field, shows that even for this long wavelength there is no rotation greater than about one radian within a substantial proportion of the line of sight. The spiral arm is at least 500 pc thick in this direction, so that the smooth region is at least 40 pc deep. Any irregularities which cause the depolarization between λ0·21 m and λ0·73 m must lie outside the uniform region, in which the product of the average electron density N_e and the line of sight component of H must be less than about $1·5 \times 10^{-8}$ gauss cm^{-3}. The observation that adjacent lines of sight, separated by 1·25°, often have different net polarizations is probably a consequence of a variable Faraday rotation in front of the smooth region.

If we suppose that the field strength is about 3×10^{-6} gauss and that it is aligned along the spiral arm in the direction $l=70°$, then the line of sight through the polarized region crosses the field at angles up to 30°. The electron density must then be less than 0·01 cm^{-3}. Even if the field follows the direction $l=50°$, the wide angle of sky covered by the polarized regions suggests that the electron density must still be less than 0·03 cm^{-3} in a considerable region of the spiral arm.

These averages of electron density refer to averages through a line of sight extending for about 50 pc; one may infer that the values around 0·1 cm^{-3} deduced from the absorption of lower frequency radio waves[6] refer to an average through discrete concentrations rather than a uniform value throughout the spiral arm.

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