AN ATTEMPT TO DETECT LINEAR POLARIZATION IN THE GALACTIC BACKGROUND RADIATION AT 215 Mc/s*

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Current theories of the mode of origin of galactic radio-frequency radiation assume the main component to be due to "synchrotron" emission by relativistic electrons in interstellar magnetic fields. Such emission is almost completely linearly polarized at the point of origin. The received radiation could, however, be substantially depolarized owing to its origin in extended regions of inhomogeneous magnetic field, or to effects associated with the rotation of the plane of polarization in ionized regions with magnetic fields along the line-of-sight. The detection of polarization is a most important observation which could substantiate the "synchrotron" emission hypothesis and provide direct evidence on magnetic fields in interstellar space.

Observations show that the received radiation, both from the discrete sources and the background, is substantially randomly polarized. Linear polarization has been detected at a level of about 5 per cent. at centimetre wavelengths, for one only of the discrete sources (the Crab nebula). Careful observations of the polarization of the background have been reported by two observers: Razin (1958), who used a method based on the rotation of a plane polarized aerial, and Thomson (1957), whose method was based on the detection of correlation between the signals received on aerials polarized in mutually perpendicular planes. Razin worked at wavelengths of 1·45 m (203 Mc/s) and 3·3 m (91 Mc/s), and, in an attempt to eliminate certain sources of error, recorded the difference in apparent polarization observed with bandwidths of 200 kc/s and 5 Mc/s respectively. He reported a difference in apparent polarization on the two bandwidths of 2–4 °K at 1·45 m over all parts of the sky observed, except in the vicinity of the Milky Way where the effect was zero. He interpreted this result as a measure of the polarization of the radiation received on the narrower band, that on the wider being assumed substantially zero owing to depolarizing effects mentioned above. The 3·3 m results were substantially less on a percentage basis and were uncertain. Thomson, observing a strip of the sky at declination 22° N. on 159·5 Mc/s with a bandwidth of 4 Mc/s, set an upper limit of 1 per cent. to the possible polarization, except in two particular regions where he states, "linear polarization of the order of 1 per cent. may have been detected". The brightness temperature was of the order of 500 °K in this case.

Razin's results, if correct, are of major importance since they imply the existence of magnetic fields and high energy electrons widely distributed throughout the galactic corona. Independent confirmation would be most valuable.

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It is unfortunate that Thomson's negative results for most of the area examined cannot be directly compared with Razin's since Thomson used a wide bandwidth for which Razin claimed that the observed polarization should be inappreciable. The present paper describes an attempt to confirm Razin's observations.

Observations were made on a frequency of 215 Mc/s with bandwidths of 1 Mc/s, and 700 and 300 kc/s, using a Dicke-type receiver connected to a fixed 60 ft paraboloid directed towards the zenith. A linearly polarized feed aerial at the focus was rotated back and forth through two revolutions and the resulting changes in output recorded.

Spurious results can arise in several ways. If the directional diagram is not circularly symmetric about the axis of the aerial, output fluctuations may arise through directional effects if there are intense sources off the axis of the aerial. We attempted to minimize this effect (1) by using for the feed aerial a 2-dipole array having nearly identical directional patterns in the E and H planes and (2) by restricting observations to times when the principal intense sources, the Sun and the centre of the Galaxy, were below the horizon.

Output changes may also arise through systematic aerial impedance changes associated with the rotation of the system. Such impedance changes were observed and corrective measures employed, but apparently a residual effect remained. A periodic fluctuation of output with rotation, simulating a polarization effect of magnitude about 1·5 °K, was observed, which remained constant in phase and amplitude over the whole of the survey. A genuine polarization effect would be expected to vary with position in the sky, as well as with time owing to changing Faraday rotation in the ionosphere, and we feel confident that this effect was spurious. We have therefore subtracted the mean fluctuation from the individual observations.

A series of observations was made in the period December 1959 to February 1960. The beamwidth of the aerial was 7° and the region observed was a strip centred on declination 34° S. and ranging in right ascension from $1^h\ 30^m$ to 10^h. The noise figure of the receiver was 3·6 (5·5 dB). We consider we could detect reliably a periodic output change ranging from 1·5 °K at a bandwidth of 300 kc/s to 1 °K at 1 Mc/s. The background temperature over this region in the sky is about 150 °K. No output changes which could be attributed to polarization were observed.

These observations set an upper limit of 1 per cent. to the degree of linear polarization over the strip of sky concerned at a frequency of 215 Mc/s and for bandwidths of 1 Mc/s, and 700 and 300 kc/s. This result conforms with Thomson's negative result for most of the region he examined. It appears to contradict Razin's claim that most of the sky remote from the Milky Way shows polarization, but it must be pointed out that Razin's and our actual observations refer to different regions in the sky, Razin's to a strip about declination 56° N., ours to one about 34° S.

A detailed account of the observations is available in a laboratory report (Harting 1960).

References

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