# OBSERVATIONS OF GALACTIC RADIATION AT 4·7 Mc/s

By G. R. A. Ellis,* R. J. Green,* and P. A. Hamilton*

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*Summary*

This paper describes observations of galactic radiation at 4·7 Mc/s using an antenna with a beam of 11° by 3°. A range of declinations from −10° to −72° and of R.A. from 1200 h to 0500 h was surveyed. Brightness contours are given.

## Introduction

At frequencies less than about 20 Mc/s the propagation of radio waves through different parts of the galaxy begins to be substantially affected by attenuation in HII regions. Shain (1954), for example, showed that at 18·3 Mc/s the optical depth in the direction of the centre is about 3 kpc. Since the attenuation is given by $\exp(-\int K\mathrm{d}S)$, where $K \sim 0{\cdot}4N^2/T^{3/2}f^2$, it might be expected that at much lower frequencies the opacity of the interstellar medium might make it possible to obtain information about the distribution in depth of both the emitting and absorbing regions. Here the results of a survey at 4·7 Mc/s are described.

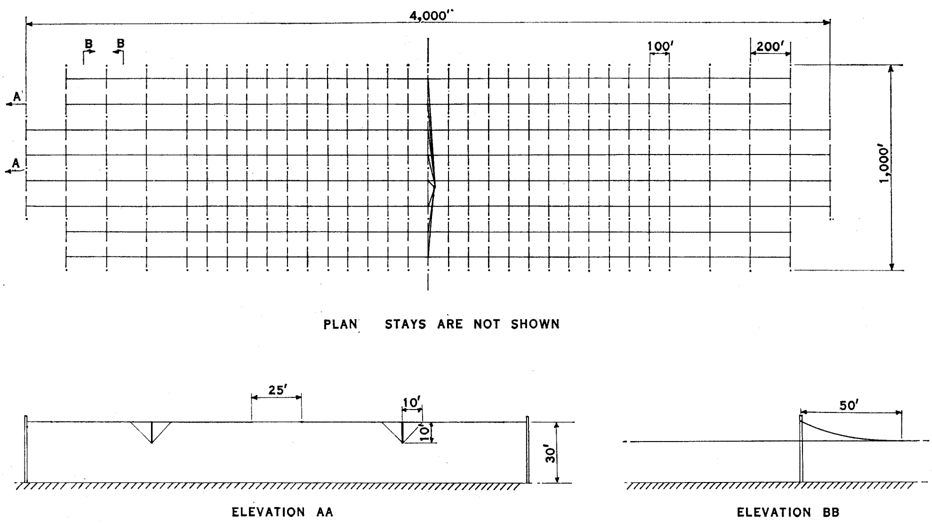


Fig. 1.—Layout of 4·7 Mc/s antenna.

## Receiving Equipment

The antenna was sited at Hobart (lat. 42·9° S., long. 147° E.). It consisted of an array of 272 horizontal half-wave dipoles 0·1 wavelengths above ground and arrayed as in Figure 1. Each dipole was connected through a quarter-wavelength

* Physics Department, University of Tasmania, Hobart.

transmission line to a terminated main transmission line which extended for the whole length of each row of dipoles. Each of the eight main transmission lines was connected at its centre through a matching network to a coaxial feeder which led to the receiving hut. Each row of dipoles was thus connected independently to the receiver. The signals passed through an eight-channel preamplifier, an eight-channel mixer and thence into six eight-channel i.f. amplifiers where they were summed with six different phase relationships to provide six antenna beams. Minimum recorders were used in the d.c. amplifiers and, in addition, to reduce interference from transmitting stations, the frequency of the main oscillator was swept through 12 kc/s five times per second. The final i.f. amplifiers had mechanical filters with a bandwidth of $2 \cdot 7$ kc/s. Figure 2 shows the calculated antenna pattern and Figure 3 the block diagram of the receiving equipment.

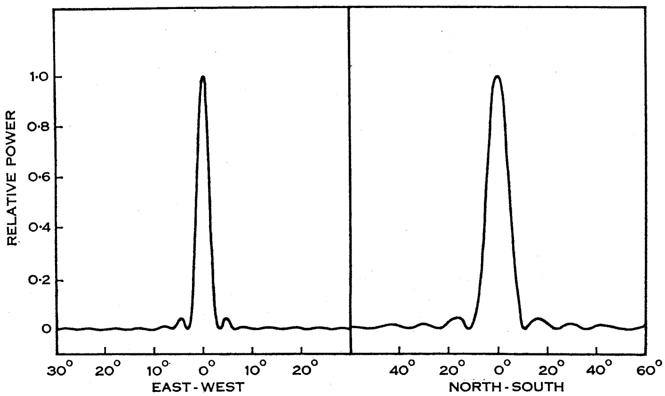


Fig. 2.—Calculated antenna pattern.

The phase of the signals in each channel was measured by connecting a signal generator to the eight inputs and observing the Lissajous patterns of pairs of the output signals at intermediate frequency on a cathode-ray tube. The phases for individual dipoles were measured in the same way, except that the signal generator was connected to pairs of dipoles via coupling loops instead of to the preamplifiers. In setting the phase differences between channels to produce an off-vertical antenna beam, a delay coaxial cable was inserted into one channel of a pair, the phases and gains of the pair were adjusted for equality, and the cable removed. Successive pairs were then aligned in this way. Phase adjustments were always made by slightly altering the resonant frequency of the i.f. transformers in the eight-channel i.f. amplifiers. The receivers were calibrated using noise generators. The overall loss in the antenna system was estimated by comparing the cosmic noise level with that from an antenna consisting of three full-wave dipoles operating at the same time and at the same frequency. For directions of high galactic latitude differences due to the spatial averaging of the smaller antenna were insignificant.

## The Observations

It was found that, providing the ionospheric critical frequency $f_0F_2$ was in the vicinity of 2 Mc/s and there was no spread-$F$ or sporadic $E$ apparent on ionospheric soundings, reproducible records of the sidereal profile could be obtained. In general the observed intensity of the galactic radiation increased as $f_0F_2$ decreased below 5 Mc/s and reached a maximum for $f_0F_2 \sim 3$ Mc/s. It has been shown that this

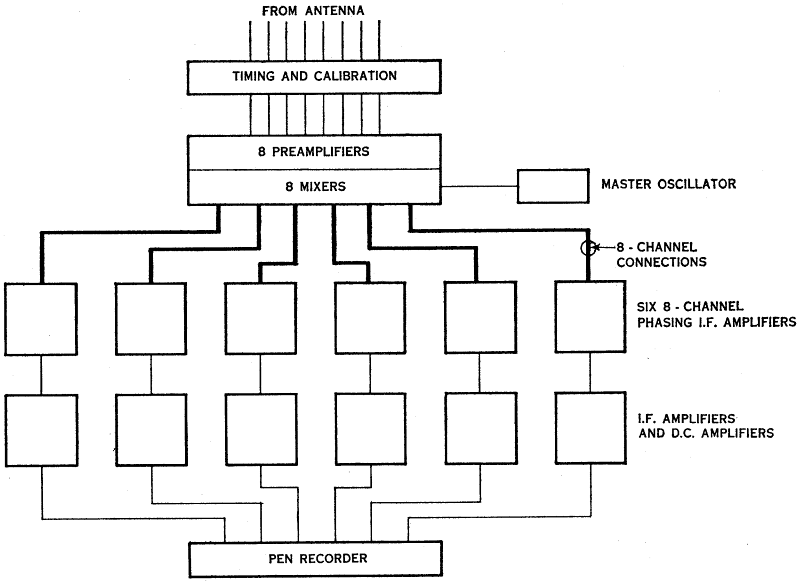


Fig. 3.—Block diagram of the receiving equipment.

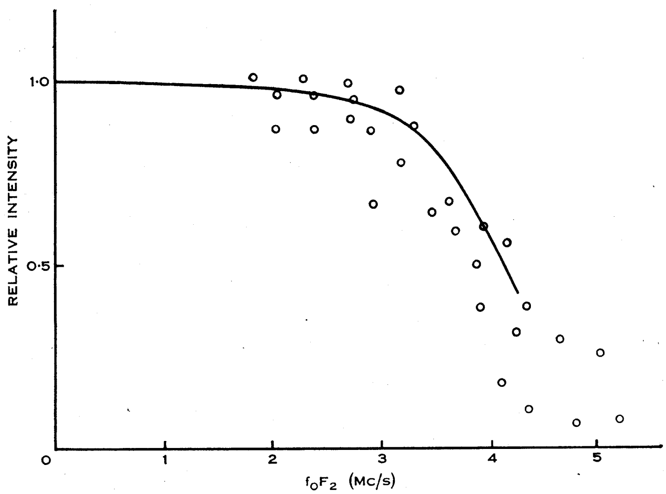


Fig. 4.—Variation in the received power at 00 h R.A. with $f_0F_2$. The solid line shows the calculated variation (after Ellis 1963).

behaviour may be expected from theoretical considerations of absorption in the $F$ region (Ellis 1963). Figure 4 shows the observed variation of the intensity with $f_0F_2$. Figure 5 shows the variation of $f_0F_2$ with local time for Hobart in June 1962.

Because of the above restrictions the number of nights for which usable records of the galactic background radiation were obtained was only 52 during the months June through September in 1962 and 1963. The facility of six simultaneous antenna beams proved very valuable in these circumstances. Much more limited was the number of occasions on which discrete detail was observed comparable in angular size with the antenna beamwidth. Normally on nights when smooth records of the background radiation were obtained discrete sources were suppressed almost completely by scintillations. Only 14 of the above 52 nights produced relatively clear records of discrete sources. The suppression of scintillating sources on the records resulted partly from the minimum recording technique, and future observations will make use of cathode-ray tube recording as described by Reber and Ellis (1956).

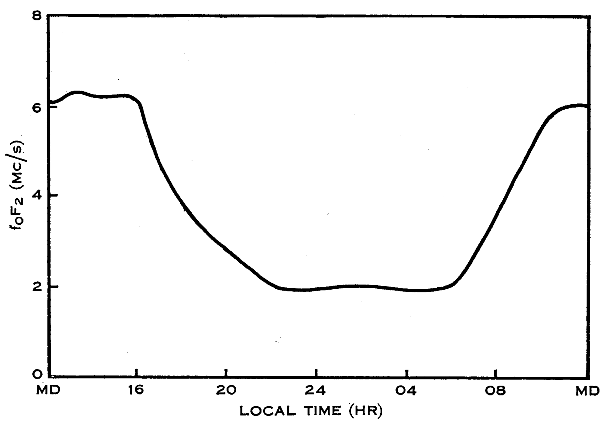


Fig. 5.—Mean values of $f_0F_2$ for Hobart, June 1962.

Figure 6 shows sample records of the background radiation for five different declinations. Features immediately evident include the absorption trough near 17 h R.A. and the external galaxy NGC 5128 at declination −42°. The records for Dec. −37° and −47° in Figure 6 give a misleading impression of the profile of NGC 5128 since these records were obtained on a different night from that for Dec. −42° and they show considerable scintillation, which is mostly absent on the latter record. Figure 7 shows the brightness contours of the background radiation in galactic coordinates obtained by using all the records which extended to 05 h R.A. Additional records to 08 h R.A. were obtained but their quality was not adequate for reliable brightness contours. The survey of this part of the sky is being repeated. Because of uncertainty about the total amount of ionospheric absorption (Ellis 1963) it is not considered that the absolute values of the intensities shown in Figure 7 can be relied upon to an accuracy better than 50%. However, the reproducibility of the records was such that the relative intensities in different parts of the sky could be measured to within 5%. For applications dealing with changes in brightness and galactic absorption with direction, the contours of Figure 7 are satisfactory, but deductions based on changes in absolute brightness with frequency should be made with caution until the ionospheric effects are investigated in more detail.

Although the records showed on occasions a considerable amount of reproducible fine detail this was in general too weak for useful deductions. In Figure 6, for example,

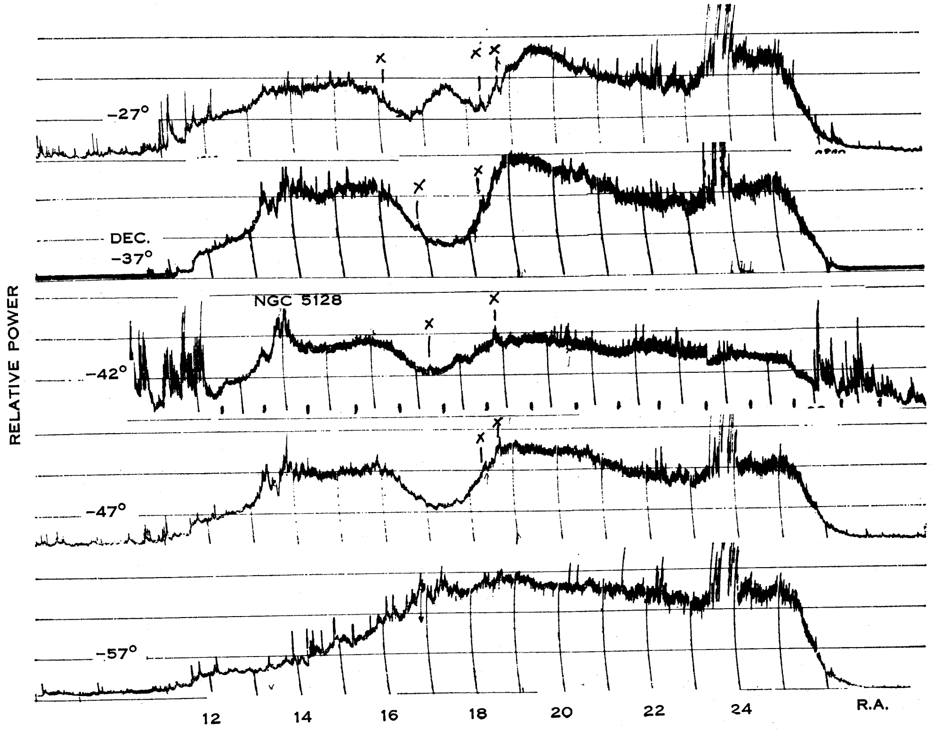


Fig. 6.—Records of the galactic profile at 4·7 Mc/s. The external galaxy NGC 5128 can be seen on the record for −42° Dec.

in the absorption trough between 16 h R.A. and 19 h R.A. small irregularities are marked with crosses. They appear to be less in angular size than the antenna beam-

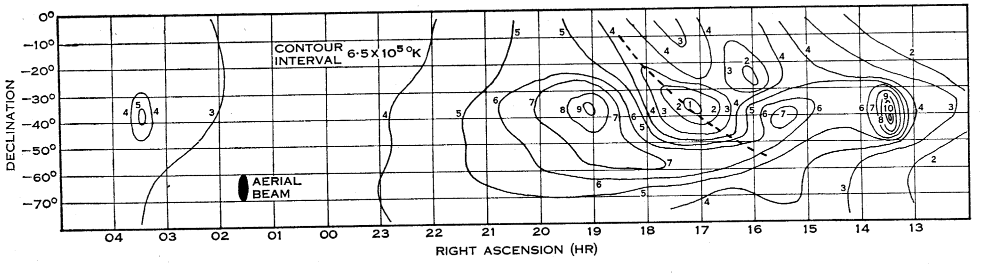


Fig. 7.—Brightness contours at 4·7 Mc/s.

width, but it was not possible to be certain whether they were caused by bright or dark objects.

The three strongest discrete sources recorded were Centaurus A (NGC 5128), Fornax A (NGC 1316), and Jupiter. Records of these are shown in Figure 8. The record for Jupiter was obtained on a night when other equipments showed that the Jupiter radiation was quasi-continuous and it therefore provides an indication of the east-west pattern of the antenna. The record for Fornax is typical in that in all cases this source appeared to be of large angular width. It is uncertain to what extent the ionosphere was responsible for the apparent size of Fornax and new observations are being made.

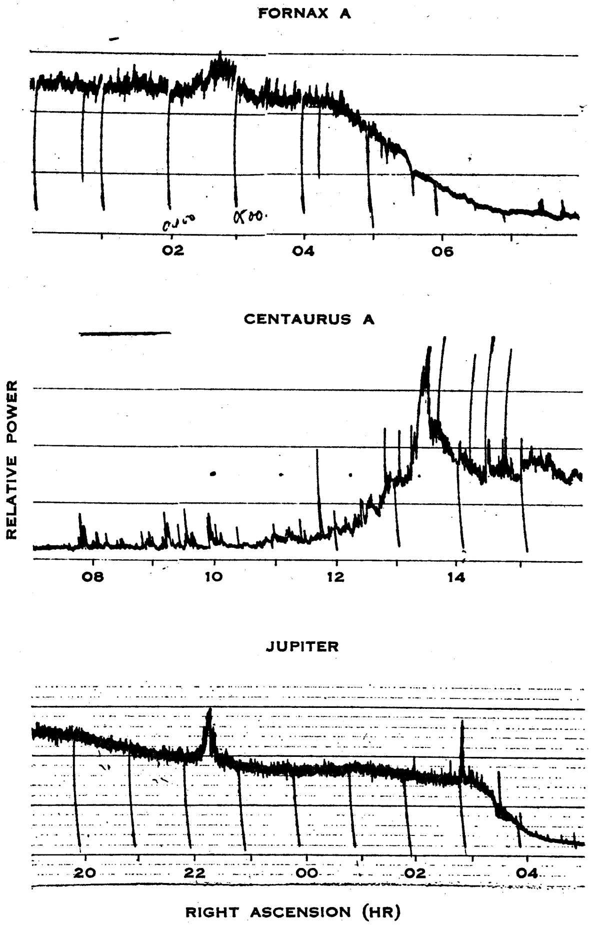


Fig. 8.—Records of three discrete sources.

## Conclusions

A detailed comparison between the brightness contours at 4·7 Mc/s and those at higher frequencies will be made in another paper. The overall features of Figure 7 agree with what might be expected from observations at higher frequencies. The darker parts correspond roughly with extensive regions of ionized hydrogen (Gum 1955), although they are brighter than calculated using existing galactic models (Hoyle and Ellis 1963).

The observations show that the distribution of brightness of the Galaxy may be measured at frequencies in the vicintiy of 5 Mc/s from beneath the ionosphere. However, the difficulties encountered through the ionospheric scintillations of discrete sources suggest that the resolution of the antenna used exceeded that needed for optimum results. Shain and Higgins (1954), for example, detected 37 galactic or extragalactic sources with an antenna 17° by 17° at 18·3 Mc/s compared to the two reported here with an antenna 3° by 11°. The angular scale of the background radiation is such that it would adequately have been recorded using an antenna with a beamwidth of about 10° by 10°.

## Acknowledgments

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