80 MHz MEASUREMENTS OF JUPITER'S SYNCHROTRON EMISSION*

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The spectrum of Jupiter's synchrotron emission was extended to lower frequencies by Gower (1968), who used a meridian transit interferometer to make measurements at 81·5 MHz. However, the elements of this interferometer had primary beams $1°{\cdot}2 \times 13°$ to half-voltage points and the correction to the observed interferometer pattern demanded by the presence of confusing sources within the primary beams was about three times the amplitude deduced for Jupiter. Consequently, it is important that an independent check be made of the measured value of 4·5 f.u.§

During the first half of 1970, measurements of the Jovian continuum were made with the 80 MHz radioheliograph operated by the Division of Radiophysics, CSIRO, at Culgoora, N.S.W. The 3 km diameter circle of 96 aerials produces 48 pencil beams (see Wild 1967), each about $3'{\cdot}7$ arc to half-power points and spaced $2'{\cdot}1$ arc in the north–south direction. Hence each beam subtends about 11 square minutes of arc and confusion problems are negligible at the flux density levels considered here.

In the present observations, the square law detector outputs corresponding to the central eight beams were passed through *RC* integrators with time constants of 2 s and recorded digitally at 2 samples per second on an incremental tape recorder. The beams were positioned to straddle the declination of Jupiter and repeatedly placed ahead of the source to record many drift scans, each of which took 64 s to complete. The drift scans were later averaged in a CDC 3200 computer. Circular polarization was accepted by the aerials during all observations.

Table 1 lists the resulting measured flux densities, each of which is an average of about 60 min observation; the measured values have been corrected to an Earth–Jupiter distance of 4·04 A.U. As the mean position of the radio source agreed with that of Jupiter to within 1′ arc on all occasions, there is only a remote possibility that the measurements are influenced by weak radio sources.

The flux density scale was calibrated each night by making drift scans through several calibration sources chosen from 3C 175, 196·1, 227, 245, 300, 313, 315, and 348, all of which have well-determined straight-line spectra (Kellermann, Pauliny-Toth, and Williams 1969). It is unlikely that errors in our calibration exceed 10%, including errors in the assumed flux of the calibration sources‖ and random errors in

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§ 1 flux unit (f.u.) = 10^{-26} W m^{-2} Hz^{-1}.

‖ There is a growing opinion (see Brande *et al.* 1970) that the flux density scale of Kellermann, Pauliny-Toth, and Williams (1969) is systematically low in the frequency range below 400 MHz. However, because of the present absence of general agreement on the magnitude of the corrections, we have not made any adjustments to the flux densities reported here.

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our measurements of them. We confined our observing periods to times when ionospheric scintillation and refraction were negligible, as indicated by various strong sources.

The average flux density from the 16 sets of observations is $6 \cdot 0 \pm 0 \cdot 7$ f.u., where the r.m.s. error includes a contribution of $\pm 0 \cdot 3$ from the statistical uncertainty of the sets of observations and a contribution of $\pm 0 \cdot 6$ from the assumed 10% uncertainty in the flux calibration.

The expected error due to system noise was estimated by examining the fluctuations about the mean baseline using the declination channels on which Jupiter was not detected. This computation was made on four nights spread over the series of measurements and resulted in an expected r.m.s. error of $0 \cdot 5 \pm 0 \cdot 2$ f.u. for a single observation. The standard deviation of the data set in Table 1 is $1 \cdot 2$ f.u., which is about twice the value that would be expected from the system noise error and leaves

Table 1

80 MHz radioheliograph observations of Jupiter

Observation date (1970)	No. of drift scans	Flux density* (f.u.)	λ_{III} (1957·0) (deg)
February 7	50	5·4	25
8	70	6·2	180
9	60	6·4	280
9	33	7·2	330
10	56	6·9	115
10	50	7·2	155
10	60	5·6	205
11	57	7·2	255
25	64	3·8	179
April 13	64	8·0	326
14	64	3·8	83
24	64	5·9	190
25	62	5·5	270
26	48	6·1	60
30	33	5·5	305
May 21	90	5·2	127

* Values corrected to an Earth–Jupiter distance of 4·04 A.U.

open the possibility of real variations in the 80 MHz flux density. Figure 1 shows a plot of the measurements as a function of the average System III longitude of the central meridian of Jupiter. The so-called equatorial beaming effect, which gives rise to a $\pm 5\%$ modulation of the received total intensity at decimetric wavelengths (see e.g. Roberts and Komesaroff 1965) cannot be seen in the 80 MHz measurements. The distribution is dominated by much larger variations in flux density, which are not apparently connected with the rotation of Jupiter's magnetosphere.

The average value of Jupiter's flux density deduced from our measurements, $6 \cdot 0 \pm 0 \cdot 7$ f.u., is higher than the $81 \cdot 5$ MHz value of $4 \cdot 5 \pm 1 \cdot 0$ f.u. obtained by Gower (1968). Assuming that there are no significant long-term changes in the emitted radiation, our 80 MHz result and the decimetric measurements (summarized by Dickel, Degioanni, and Goodman 1970) suggest that the Jovian spectrum is substantially flat down to at least 80 MHz. This result does not support the claim of Gleeson, Legg, and Westfold (1970) that the total radio intensity below 300 MHz varies as the one-third power of the frequency; hence we suggest that the evidence for a low energy cutoff in the relativistic electron distribution must be seriously questioned.

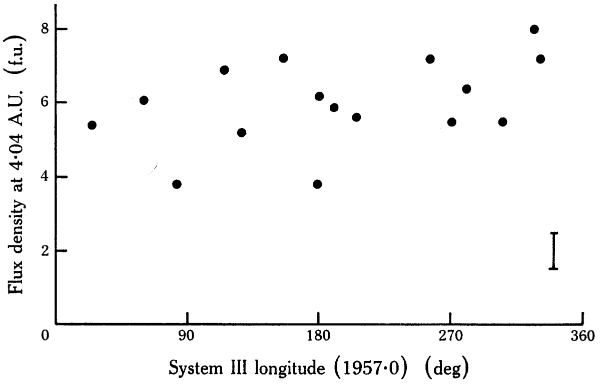

Fig. 1.—Average values of Jovian flux density, normalized to a standard distance of 4·04 A.U., plotted against the average System III longitude (I.A.U. System III 1957·0). The error bar in the lower right corner shows the expected r.m.s. error in each measurement due to the system noise.

Because of the long integration time required just to detect Jupiter at 80 MHz, we were unable to measure the amount of linear or circular polarization. With improvements in the system sensitivity we hope to make polarization measurements and to establish the possible variations in flux density.

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