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Search for Jovian Hectometric Continuum Radiation

Several observers have reported essentially continuous radiation from Jupiter at low frequencies. Dulk and Clark[1] believe Jupiter to be continuously emitting weak radiation at and below 10 MHz. They found the minimum flux at 10 MHz to be 5×10^{-23} W m^{-2} Hz^{-1} on all but one occasion. McCulloch and Ellis[2] measured a mean flux of 10^{-21} W m^{-2} Hz^{-1} at 4·7 MHz although it was frequently below this level. They remark that at low frequencies weak radiation from Jupiter is nearly always present. Slysh[3] proposed that the intense, constant radiation observed at 200 kHz from several spacecraft was chiefly of Jovian origin. He suggested that a spectral index of 2·5 may hold from 0·20 to 20 MHz. If this were correct it should be possible to detect the Jovian continuum with the Radio Astronomy Explorer satellite (RAE–I).

RAE–I was launched on July 4, 1968, into a 5,860 km retrograde circular orbit of 59° inclination and period 3 h 44 min. It has two oppositely directed 229 m V antennas and one 37 m dipole. The antennas are connected to radiometers which cover 0·20 to 9·2 MHz.

There are two methods for identifying Jovian emission with RAE–I. One method is from the scan of the main beam of the upper V antenna past Jupiter when the orbit permits. The second method is provided by a lunar occultation of Jupiter as seen by the satellite. The lunar occultation provides a more sensitive test and has been investigated in detail.

There were eight "optical" occultations expected between July 1968 and December 1969. Three were contaminated with either magnetospheric noise from the Earth or solar activity; for these three events the sensitivity to Jupiter was thereby reduced by a factor of about five. The effects of refraction between Jupiter and the Moon and from the Moon to RAE–I were computed to establish that there was in fact an occultation taking place at our observing frequencies along with the optical event. For four of the remaining five cases there was no occultation visible below 1 to 2 MHz. There were very favourable conditions for observing the occultation on April 29, 1969. For this event Jupiter came within 5 arc minutes of the centre of the Moon.

None of the occultations observed so far took place when the V antenna was pointed at Jupiter, so only the dipole data were analysed. The orientation of the dipole antenna was found in order to determine its directivity toward Jupiter. For all the occultations this directivity was close to unity for frequencies below 2 MHz.

Radiometer data from all the occultations have been analysed for any evidence of the disappearance or reappearance of Jupiter. This would be shown by a Fresnel diffraction pattern or at least by a shift in the average level at the time of occultation. But we have found no evidence for Jovian radiation greater than our sensitivity limit.

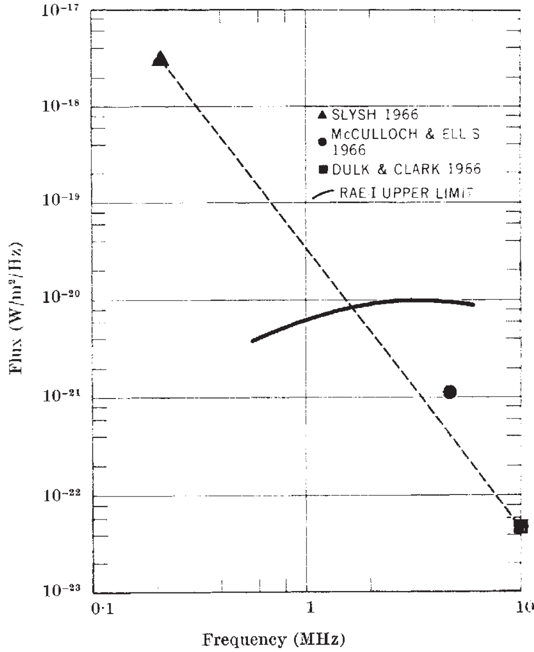

Fig. 1. Jovian continuum radiation.

An upper limit to the Jovian continuum of about $1/4\pi$ of the background flux[4] can be set based on the occultations and the satellite receiving system. This limit assumes that the continuum source was totally occulted by the Moon. The useful frequency range for these occultations is 0·54 to 5·4 MHz. The minimum frequency for each occultation depends on ionospheric conditions and on the Jupiter–Earth–satellite geometry. Fig. 1 shows the upper limit derived from the RAE–I observations as well as other low frequency Jovian observations. At the lowest frequencies this upper limit is a factor of twenty or more below a simple power law spectrum obtained by joining the 0·20 MHz observations with higher frequency ground-based observations. The RAE–I upper limit rules out the suggestion of a relatively constant spectral index from 0·20 to 20 MHz for a continuum component. Moreover, it makes the 0·20 MHz observations difficult to explain in terms of Jovian emission. From RAE–I and ground-based data it is reasonable to conclude that the radio spectrum turns over somewhere between 0·5 and 3 MHz. Additional occultations may provide lower frequency data to help settle this question.

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