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Radio Observations of Compact Sources in the Outer Solar Corona

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Abstract

We have observed radio emission from the solar corona at a frequency of 77 MHz during the total solar eclipse on October 24, 1995 from our observatory at Gauribidanur. Sources of angular sizes $\leq 1.5'$ have been found to exist at heights 0.4 $R_{\odot}$ above the photosphere.

Key Words : Solar eclipse - radio emission - scattering

Introduction

The association of localised sources of radio emission at centimetric and decimetric wavelengths with visible features on the solar disk is reasonably well established by several authors. However at frequencies $\leq$160 MHz, such a clear association is yet to be established. Eclipse observations of the radio emission from the outer solar corona can be used to look for possible existence of discrete sources of radio emission and their association with features seen in the visible wavelength range because of the high spatial resolution that can be obtained. We present here the results of the radio observations at 77 MHz made at the Gauribidanur radio observatory (Long: 77°26'12" E, Lat: 13°36'12" N) during the total solar eclipse of October 24, 1995.

Lunar Occultation technique

Observations made during an eclipse provide very high angular resolution (Correia *et al.* 1992) given by the first zone of the Fresnel diffraction pattern, i.e.

$$\theta_f = 2 \times 10^5 \, (\lambda / 2D) \text{ arcsec}$$

where λ is the wavelength of observation and D is the Earth-Moon distance. The duration of the occultation is given by (Hazard, 1962),

$$T\ (\text{sec}) = (2s\ /\ b)\cos\theta$$

Where s - Semi-diameter of the moon.

b - Apparent rate of movement of the moon in the sky.

θ - Angle between the source and center of the moon.

The size of the occulted source can be estimated from the time taken by the observed intensity to fall to the minimum value during immersion and/or by the time taken to rise to the pre-eclipse level during emersion (Hazard, 1976).

Instrument

At Gauribidanur the eclipse was partial with a maximum magnitude of 0.6123 and an obscuration of 0.5212. Observations of the solar corona were carried out using a specially built antenna system. An array of 8 log-periodic dipoles was set-up as a North-South interferometer with a baseline of 21 meters. Each arm of the interferometer had 4 antennas with an inter-element spacing of 7 meters. The antennas were tilted towards the East in such a way to maximize the response pattern of the array on the Sun at the time of maximum phase of the partial eclipse which occurred at 3:08:35 UT as seen from the observatory's longitude. It was not necessary to track the sun as the beamwidth between the half-power points in the East-West direction was very broad (~ 90°). At 77 MHz, the effective collecting area is approximately 64 m^2 and the minimum detectable flux density is about 100 Jy. In the present observations, an integration time of 2 seconds was used which gave a resolution of approximately 14" in a direction perpendicular to the limb of the moon.

Results

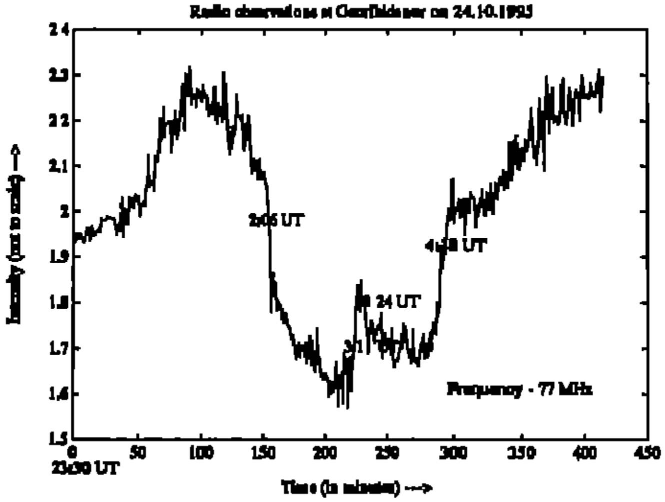

Figure 1. The intensity measurement of the solar corona at 77 MHz during the total solar eclipse of October 24, 1995.

The observed eclipse curve in Figure 1 shows the disappearance of 2 discrete sources at times 2:06 UT and 3:24 UT. Both the sources reappeared after a duration of 65 and 56 minutes at time 3:11 UT and 4:20 UT respectively. The estimated sizes of the two radio sources are ≤ (1.5' ± 0.5'). This is the first time at meter-decameter wavelengths, enhanced density regions of this small dimension have been found to exist in the outer solar corona. Assuming equal E-W and N-S diameters, the brightness temperature for the two sources were calculated and the values are 2.7×10^8 K and 3×10^8 K respectively for the first and the second occulted sources.

Discussions

It has been suggested that scattering by electron density irregularities increases the apparent sizes of coronal sources and this hypothesis is usually invoked by several authors (Thejappa and Kundu, 1994; Riddle, 1974) to explain the observed low brightness temperature of the outer solar corona. Mclean and Melrose (1985) pointed out that there is no unambiguous evidence to show that scattering is important in any of the burst sources that exhibit fine structure. Sources smaller in size than those predicted by the scattering theory had been observed previously by Kerdraon (1979) as in the present observations. It is therefore necessary to evaluate further the effects of scattering particularly on the sizes of radio sources in the outer corona.

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