Bull. Astr. Soc. India (1998) **26**, 233-236

Some initial results from the Gauribidanur radio heliograph

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Abstract. Observations of the Sun at two frequencies (51 and 77 MHz) using the East-West arm of the Gauribidanur Radio heliograph are presented.

1. Antenna system

A radio heliograph operating in the frequency range of 40-50 MHz has been constructed at Gauribidanur (Long: 77°26'26", Lat: 13°36'26"N) by the Indian Institute of Astrophysics (Subramanian et al. 1995a). This radio heliograph will produce images of the solar corona at several frequencies in the above frequency range. The heliograph is in the form of letter "T" with the long arm along the East-West direction and the short arm along the South direction. This telescope consists of 192 antenna elements, with 128 in the East-West arm and 64 in the South arm. The basic element used in this array is a log periodic dipole designed to operate in the above frequency range with a VSWR<2. These elements are linearly polarised in the East-West direction. In the East-West arm 128 log periodic elements are arranged with an interelement spacing of 10 meters and in the South arm 64 elements are arranged with an interelement spacing of 7 meters. The RF signals from each group are brought to the laboratory and down converted to an IF of 10.7 MHz.

In the completed heliograph, 128 elements in the E-W arm would be divided into 16 groups of 8 elements each and 64 elements of the South arm would be divided into 16 groups of 4 elements each. A 1024 channel digital correlator is being built to obtain all possible correlations of the 32 (16 E-W & 16 S) antenna outputs. Multi-frequency operation would be achieved by making observations sequentially at 3 or 4 frequencies. The dwell time at each frequency would be approximately 100 milliseconds. (Subramanian et al. 1995b).

2. Observations

During early 1995, one dimensional observations on Sun and other strong sidereal sources were carried out with the East-West arm divided into 8 groups of 16 elements each. The outputs from these groups were correlated in a 64 channel digital correlator. Phase corrected outputs from the 7 baselines were added together to synthesize one dimensional scans of the Sun at 51 and 77 MHz. The scans were CLEANed with the observed E-W beam on a point source. The Sun was relatively quiet and no transient burst activity was seen during the present observations. The radio source Tau-A was used as a calibrator. The variation of the gain of the array with zenith distance was determined by observing strong radio sources at different declinations. The integrated solar fluxes were corrected for this effect. The error in the measurement of the fluxes is estimated to be about 20% at both the frequencies. During the period Jan 5 to Feb 14, 1995 the observed flux densities varied from about 2750 Jy to 7634 Jy at 51 MHz and from 7128 Jy to 19832 Jy at 77 MHz. The E-W half-power diameter varied from about 44' to 56' at 51 MHz and from 33' to 47' at 77 MHz. The brightness temperature varied from about 0.23×10^6 K to 0.62×10^6 K at 51 MHz and from 0.42×10^6K to 0.8×10^6 K at 77 MHz. The daily values of the brightness temperature, the integrated flux density and

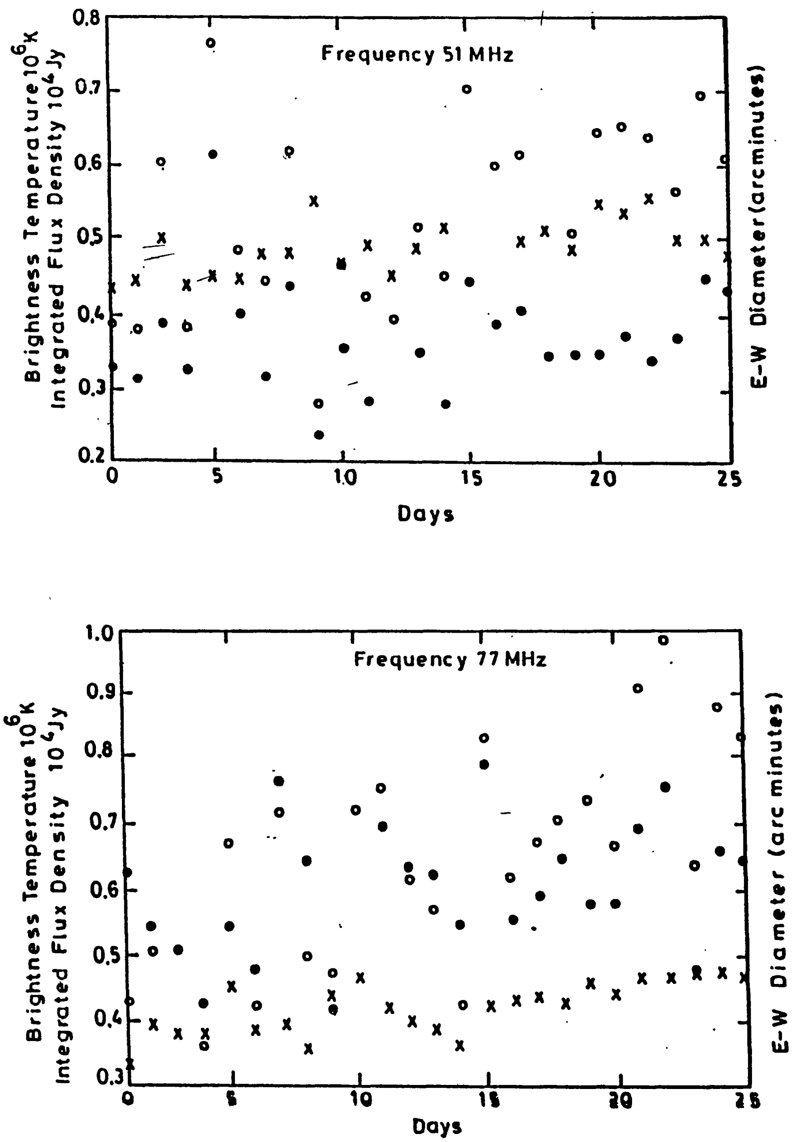

Figure 1. A plot of the daily variation of the brightness temperature (open cir, integrated flux density (filled circles) and E-W diameter (crosses) during the period Jan - Feb, 1995.

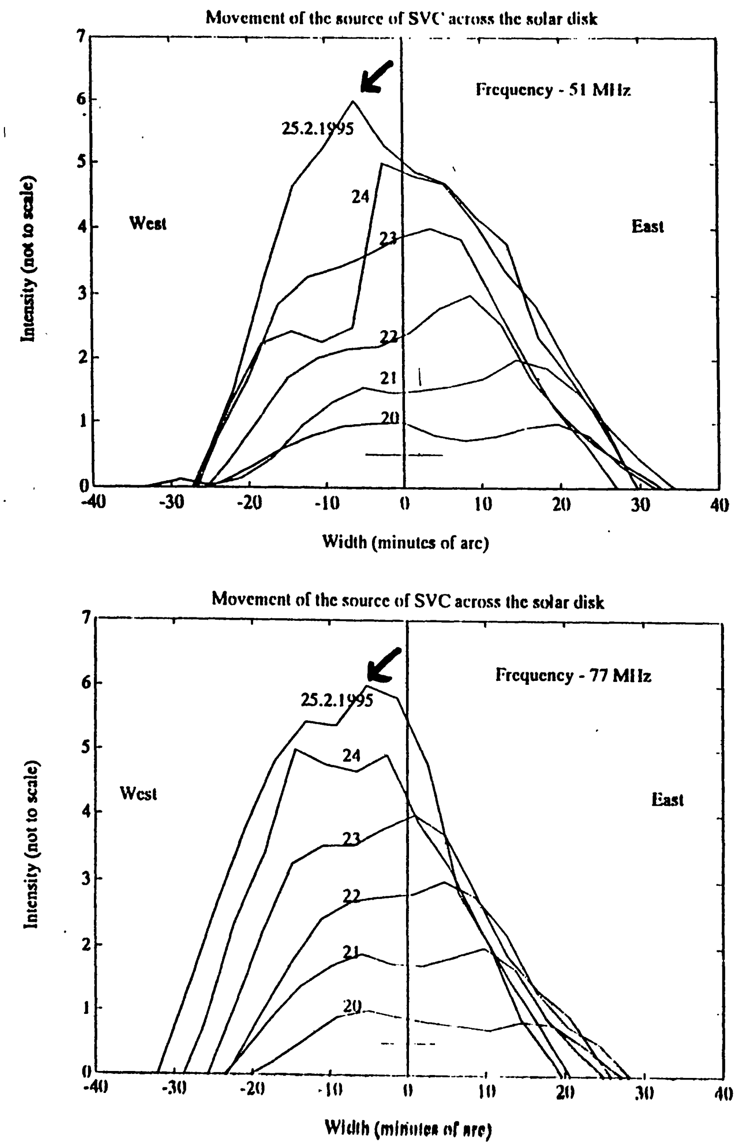

Figure 2. A plot of the regular movement of the peak of the observed emission during the period Feb 20 - Feb 25, 1995. The horizontal bar indicates the beamwidth and the arrow mark indicates the peak of the observed emission.

the E-W diameter of the Sun at 51 MHz and 77 MHz are shown in Figure 1. The E-W half-power diameter and the flux densities of the Sun obtained by us are consistent with Sheridan and McLean, (1985).

Also from the observations made during the period Feb 20 to Feb 25, 1995 we noticed emission from an enhanced density region in the solar corona. The source was persistent in our scans taken at both 51 MHz and 77 MHz during the above mentioned period and it moved from east to west on the solar disk regularly with the Sun's rotation. Figure 2 shows the regular rotation of the peak of the observed emission during the above mentioned period. The measured rotation rates were 6' at 77 MHz and 7' at 55 MHz.

3. Discussions

The half-power widths of the observed scans remained approximately constant at both 51 and 77 MHz during the period Jan 5 to Feb 14, 1995. The variations in the brightness temperature and the variations in the integrated flux densities are correlated. There is no correlation between the variations in the brightness temperature and the half-power widths. We therefore believe that the observed variations in the brightness temperature are not due to the scattering of the radiation by coronal irregularities.

From the observed rotation rate of the persistent source and using the formula (Moutot and Boischot, 1961),

$$h = (\alpha \cos (L)\, d/\beta) - R_o$$

where h- Altitude of the active region above the photosphere

α - Apparent rotation of the active center in 24 hours

L - Heliograph latitude of the active region

β - Rotation of the Sun in 24 hours

d - Earth-Sun distance

R_o - Radius of the Sun.

The altitude of the active region above the solar photosphere was found out and the values are 0.67 R_o at 51 MHz and 0.47 R_o at 77 MHz. We have used $L = 20^\circ$ in our calculations since normally during solar minimum the active regions are situated approximately around this latitude (Moutot and Boischot, 1961). Since the radiation at any given frequency originates at or above the corresponding plasma level, the electron density can be calculated. In the present case the density at heights 0.67 R_o and 0.47 R_o above the photosphere are 3.2×10^7 cm^{-3} and 7.3×10^7 cm^{-3} respectively. These observations indicate the possibility of using multi-frequency radio imaging at meter-decameter wavelengths as an effective tool for estimating the electron density of various layers of the solar corona without assuming any density models.

References

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