DETERMINATION OF THE DECAMETER WAVELENGTH SPECTRUM OF THE QUIET SUN

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Abstract. The Teepee Tee array of the Clark Lake Radio Observatory has been used to compare the flux of the Sun with that of the sidereal sources Tau A and Vir A at several frequencies in the range 109.0-19.0 MHz. Only the two central banks of the E-W arm of the array were used as elements of a phase switched interferometer so that the Sun could be observed as a point source and compared directly to the sidereal sources. The Sun was still partially resolved however, and appropriate corrections for this effect were made. The observations were taken at times when the Sun and either Tau A or Vir A were at the same declination. We have therefore been able to derive the values for the solar flux, without having to resort to a gain vs zenith distance correction. The observations, combined with those available in the literature, allow us to derive an accurate meter and decameter wavelength spectrum of the quiet Sun.

Determination of the flux density and of the brightness distribution of the undisturbed Sun at the meter and decameter wavelengths provides a very useful method of obtaining information about the density and temperature structure of the corona. Despite some measurements carried out over the last few years (Aubier et al., 1971; Sheridan, 1970; Kundu et al., 1977), our knowledge of the solar spectrum in this wavelength range is limited. Interest in this part of the spectrum is enhanced by a disagreement, pointed out by Chiuderi et al. (1972) and more recently by Dulk et al. (1977), in the coronal models which can be derived from currently existing radio data and those obtained from observations of EUV lines. In particular, the EUV observations imply either temperatures about twice as high (Chiuderi et al., 1972), or densities several times higher (Dulk et al., 1977) than those derived from the radio brightness measurements.

Only a few measurements of the flux density of the quiet Sun are available at frequencies below 100 MHz (\(\lambda = 3\) m). Almost all of these have been obtained at different times within the last two solar cycles. At 169 MHz, the flux density has been claimed to vary by as much as 100% between periods of minimum and maximum activity (Leblanc and Le Squeren, 1969). A similar behaviour might be

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expected at lower frequencies as well, and lead to inconsistencies between measurements of different parts of the spectrum. The observations have also been taken with instruments of widely different types. In most cases, the flux of the quiet Sun was determined by comparison with one or more of the four strong radio sources: Cas A, Tau A, Vir A or Cyg A. Slightly different flux scales have been used for these calibrators by the different observers.

The determination of the solar flux density at the low frequencies is difficult because: (1) Most determinations have been obtained by integrating one or two dimensional brightness distributions of the Sun, after eliminating contributions attributed to active regions. At low frequencies the sky-background temperature rises and the solar brightness becomes low. The resulting low contrast makes baseline determination and subtraction difficult, resulting in uncertainties of 10–20%. (2) Few calibrator sources with accurately determined spectra are available. (3) Since the calibrator sources generally differ in declination from the Sun, accurate determination of the gain vs zenith distance relation for the system employed is required. The determination of this relation is often difficult.

We report here on two recent series of measurements in course of which some of the potential sources of error have been eliminated. We used the Teepee Tee array of the Clark Lake Radio Observatory to determine the solar spectrum in the frequency range 109.0 to 19.0 MHz. The observations were obtained between July 16 and July 23, 1976 for the first series of measurements, and between August 18 and August 21, 1976 for the second series. Seven frequency bands, at 109.0, 73.8, 57.7, 38.1, 30.9, 25.8, and 19.0 MHz have been selected because from previous experience, they were known to be relatively interference-free. At 19.0 MHz we have been able to estimate only an upper limit to the solar flux. A 150 kHz bandwidth has been used for all determinations except at 19.0 MHz where a 50 kHz bandwidth was used.

A detailed description of the Teepee Tee array has been given by Erickson and Fisher (1974), and only some features relevant to the present experiment will be mentioned here. The complete array consists of 720 conical spiral antennas, laid out in the form of a T, with the directions of its arms being east, west and south. The elements are grouped into banks of 15, phasing within a bank is accomplished by electronically 'rotating' each antenna. The E–W and N–S arms are formed by 32 and 16 banks respectively. Only the two central banks of the E–W arm were used in both series of observations as elements of a phase-switched interferometer in order that the Sun could be observed as a point source and compared directly to sidereal sources. The distance between the phase centers of the two banks is 93.75 m; however, the solar disk was still slightly resolved. A correction for this effect was made and will be described later.

Antenna steering and data acquisition are computer controlled, allowing nearly instantaneous switching between several celestial sources. This feature made possible the simultaneous observation of the Sun and a calibrator source. Tau A (3C144) and Vir A (3C274) were selected for calibration. Both sources are strong