CORONAL STRUCTURES OBSERVED AT METER WAVELENGTHS

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ABSTRACT. Two dimensional maps obtained with the Nançay Radioheliograph at 169 MHz from 1980 are used to describe and identify the features of the quiet sun at meter wavelengths.

The Mark III Nançay Radioheliograph (Radioheliograph Group, 1983) observed the Sun at 169 MHz (λ = 1.77 meter) with a time resolution of 25 East-West and North-South images per second. When the brightness distribution of the Sun is stable during the six (or eight) hours of daily observation, a two dimensional map can be computed taking advantage of the rotation of the axis of the E-W and N-S arrays in the frame of the Sun (Alissandrakis et al., 1985). The best images are obtained from April to August when the declination of the Sun is high enough to give a good coverage in the plane of harmonics and a reasonable North-South resolution. The space resolution is 1.5' East-West and, in summer, 3.5' North-South (half power width). The maps are calibrated using Cygnus A as reference.

The Mark III Radioheliograph is working since 1980. Thus for the first time a meter wavelengths a large number of calibrated maps is available, allowing a systematic study of a coronal structures. In particular variations of the meter wavelength brightness during the solar cycle can be studied.

In agreement with Dulk and Sheridan (1974), our maps show an intensity distribution with a flat top, a rapid drop near the half maximum level and an extended low brightness emission on the limb. During the cycle maximum (1980) the flat top has a brightness temperature of 800,000 - 900,000 K and it covers almost entirely the photospheric disk (Figure 1a). During the decreasing phase of the activity cycle (1984), the flat top brightness temperature drops to 600,000 - 700,000 K and is less extended because of the frequent presence of coronal holes (Figure 1b). This background component of the quiet sun is clearly related to the thermal emission of coronal loops outside active regions as seen on X-ray Skylab photographs.

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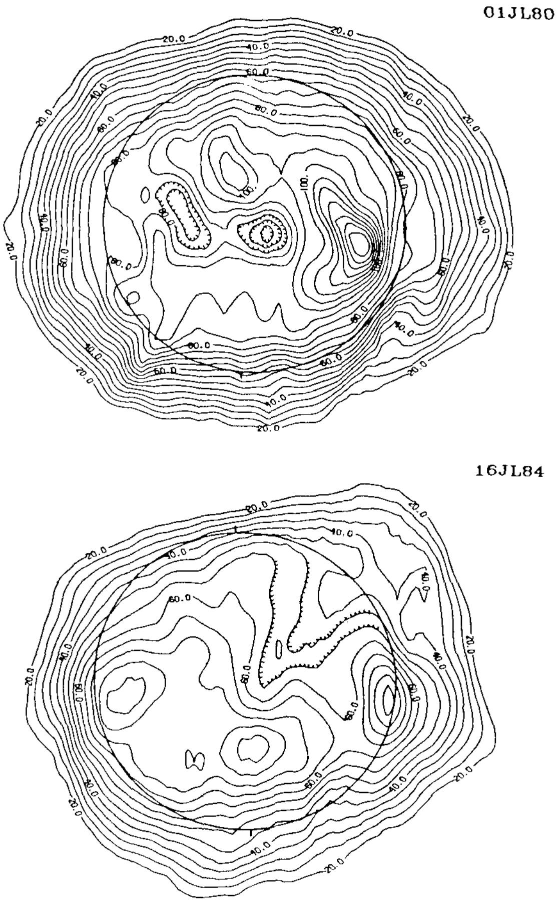

Figure 1 :
Maps of the Quiet Sun at 169 MHz on July 1st, 1980 (1a) and on July 16, 1984 (1b). A noise storm continuum is visible as a bright emission on both maps, close to the west limb. Other sources are thermal emissions. Depressions on the disk (hatched contours) are coronal holes. Brightness temperature contours are labeled in 10^4 units.

Above active regions with sunspots, no localized thermal emission is detected. This is due to the density of the active region loops ($N_e = 10^9$ cm^{-3} according to Pye et al., 1978) which is greater than the critical density at 169 MHz ($3.5\ 10^8\ cm^{-3}$) : the coronal loops reflect the radio waves coming from the surroundings. On the other hand non-thermal emissions are seen close to the spotted active regions. They are not above the active regions but displaced by a few arc minutes and they are varying in location and in intensity from day to day. The characteristics are those of noise storm continua. Furthermore with high time resolution data of the Radioheliograph a few faint Type I bursts are detected at the same location. The brightness of the noise storm continua ,of about one million K ,is much lower than for usual noise storms whose brightness temperature is frequently greater than 10^8 K (Kerdraon and Mercier, 1983).

Thermal localized emissions are also present every day on the disk. Some sources are above Hα filaments : this component has been recognized previously by Axisa et al., 1971 using fan beam (HPBW = 3.4') observations and synoptic maps. Other sources are not above Hα filaments (seen on daily spectroheliograms or synoptic maps). As they are located above inversion lines of longitudinal magnetic field and they are likely thermal emissions of coronal loop systems brighter than the surroundings. The altitude of thermal localized sources, deduced from their rotation is about 0,23 solar radius.

Coronal holes are well observed on the disk as depressions of the background. Figure 1 shows typical examples during the maximum of the cycle (1a) and during the decreasing phase of the solar cycle(1b) (similar to the Skylab period) when coronal holes are extended in latitude.

From the comparison with other radio wavelengths (from millimeter to decameter range) we gain a three dimensional view of the corona because higher frequencies penetrate more deeply in the atmosphere than the lower one. A comparison of decameter maps obtained at three frequencies with the Clark Lake Radioheliograph with the Nançay meter wavelength maps shown very bright decameter sources without counterpart at meter wavelengths. The exact nature of such sources, thermal or not, is presently unknown.

As numerous maps are available at meter wavelengths, synoptic maps can be plotted, on the disk as well as on the limb. The comparison of meter wavelengths and K-corona polarization maps on the limb shows that the synoptic maps are rather similar. Nevertheless as radio waves are sensitive to electron temperature, it will be possible to add a temperature diagnostic to the density diagnostic deduced from the K-corona observations. This complementary of information is of particular interest for the solar wind source models.

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