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LARGE SCALE STRUCTURE OF THE SUN'S RADIO CORONA

M. R. Kundu
Astronomy, Program
University of Maryland
College Park, MD 20742, USA

ABSTRACT

We present results of studies of large scale structures of the corona at long radio wavelengths, using data obtained with the multifrequency radioheliograph of the Clark Lake Radio Observatory. We show that features corresponding to coronal streamers and coronal holes are readily apparent in the Clark Lake maps.

INTRODUCTION

The Clark Lake multifrequency radioheliograph, which has been operating for several years, produces 64 x 64 pixel solar images (of 0.5 HPBW x 0.5 HPBW per pixel) within the frequency range 20-125 MHz. The field of view and the angular resolution of the telescope are both frequency dependent. The field of view is approximately 2°.3 x 1°.9 at 80 MHz, when observing at the zenith. It scales inversely with frequency (in both dimensions), and is larger because of foreshortening when observing away from the zenith. The angular resolution ranges from 2.7 arc min at 125 MHz, to 17 arc min at 20 MHz. The telescope is electronically steered for pointing in different sky directions, and is continuously tunable across the entire frequency range. In practice, one is restricted to observe within interference-free bands. Several such bands are available. In this paper we shall concentrate on the results obtained at 38.5, 50.0 and 73.8 MHz. The sensitivity of the system is about 1 Jy (10^{-4} solar flux units) at all frequencies. At the present time we have the capability of producing two-dimensional images of the Sun at the rate of one picture every 0.6 seconds. We use this fast rate of imaging only when the Sun is active. For synoptic studies of the Sun, we use much slower time resolution (~ 1 to 3 minutes). The array receives lefthanded (LH) circularly polarized radiation (Kundu et al 1983). In this paper we present results obtained by the Clark Lake instrument on large scale structures of the corona.

1. Large Scale Structures of the Corona

We obtain representative "daily" maps of the Sun at several frequencies in the 25 to 110 MHz range. The maps as presently obtained during periods of low and moderate activity permit us to study the large scale structure of the corona in the height range 1.5 -3.0 $R_{\odot}$. Figure 1 shows a sequence of CLRO maps at 50 MHz. The cross in the center of each map gives the disk center position, with bar lengths equal to the solar photospheric diameter, and the north arrow indicates the direction of solar north. The sequence of maps covers nearly one solar rotation (Carrington No. 1754), with the exception of a few days of absent data. The letters "A-I" indicate longlived sources, "a" and "b", shortlived ones, and "CH" a coronal hole. All of the sources except G appear to rotate with

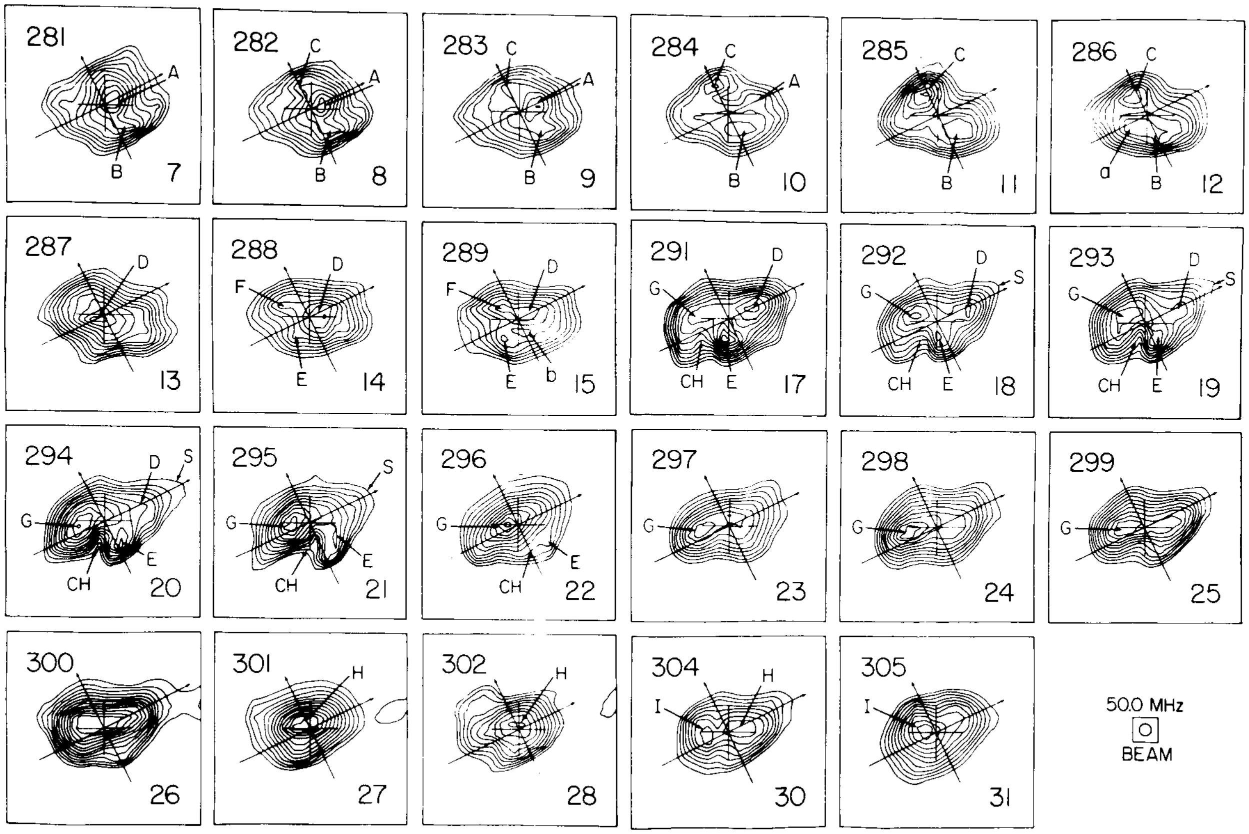

Figure 1. CLRO maps at 50 MHz for October 7-31, 1984. The central cross shows sun center; its arms extend out to one solar radius. The beam size is shown by the ellipse in the upper left corner of the first map. The arrow on each map points to solar north (see text for details).

the solar rotation rate. The letter S points to one of the extended lobes that is strongly associated with a streamer seen in SOLWIND coronagraph images.

One of the most striking features of the radio maps seen at 50 MHz and also at 73.8 and 30.9 MHz is a coronal hole on the disk, whose central meridian passage occurred on day 295 (October 21). Fig. 2 shows He 10830Å maps of the "footprint" of the coronal hole at the chromospheic level along with 30.9, 50 and 73.8 MHz maps. The He 10830Å "hole" is also sketched on the radio maps. Note the excellent agreement of the He 10830Å and 73.8 MHz "holes" on October 19-21. This might imply that the 73.8 MHz hole extends down close to the chromospheric level. However, at 50 MHz, the hole appears further east, and still further east at the lowest frequency (30.9 MHz). Since the source heights at the lower two frequencies are (roughly) 1.5 and 1.7 solar radii, the maps show that the coronal hole bends eastward through ~ 30-45 degrees of longitude at heights ranging from 1.0 to 1.7 radii. This backward bending of the hole is in the same sense as the "garden hose" Archimedian spiral suggested for the solar wind (Kundu et al 1986).

In general, lobe-like structures in the radio maps show spatial association with persistent white light streamers in the coronagraph images and the minima (contours drawn toward the sun center) correspond to coronal holes. The radio coronal holes have excellent correspondence with the coronal holes depicted on He 10830Å images.

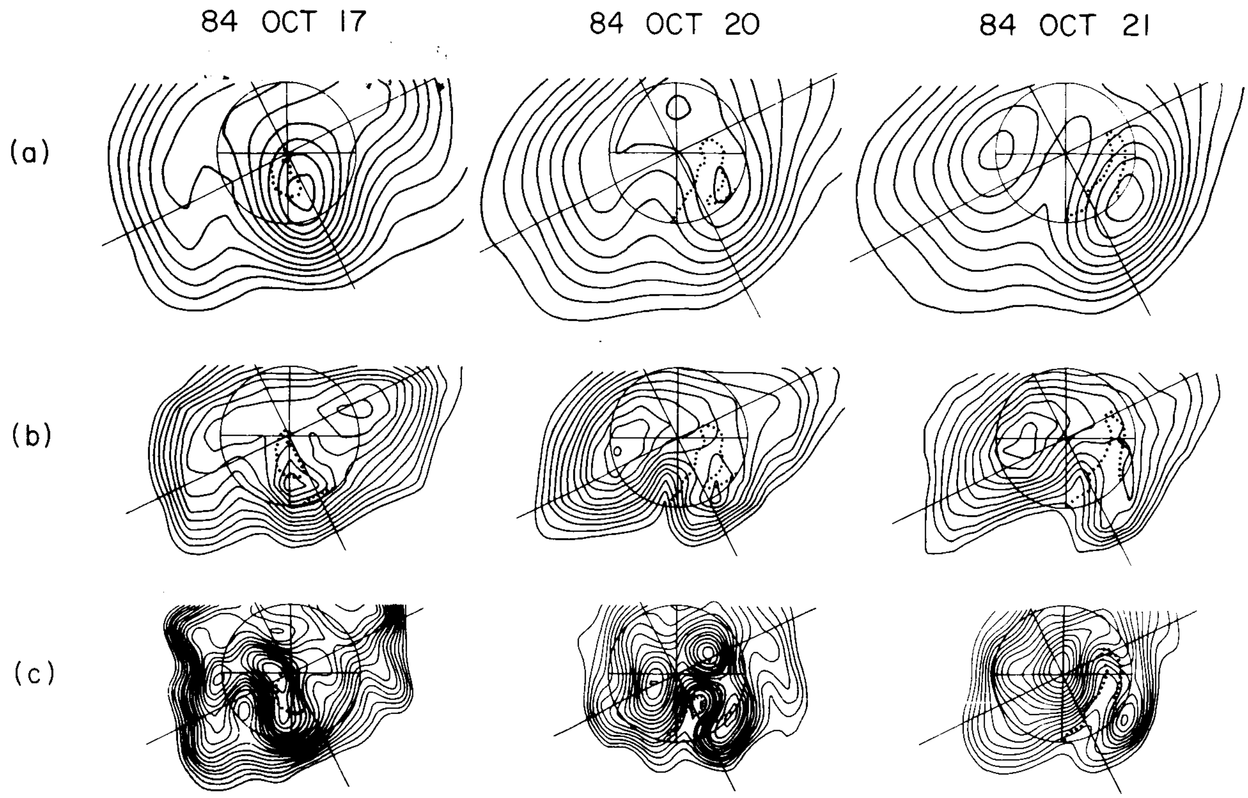

Figure 2. CLRO maps on October 17, 19 and 21, 1984 showing the coronal hole at a) 30.9, b) 50 and c) 73.8 MHz. The 10830Å hole boundary is shown by the dotted curves on each of the radio maps. On October 19 and 21, the correspondence is excellent between the 73.8 MHz contours and 10830Å, which may mean that at this frequency the hole extends down close to the chromospheric level. However, the hole appears displaced eastward as one moves to lower frequencies (greater heights), indicating a backward bending of the hole.

Taking constant radius scans on the "daily" maps at each observed frequency we produce synoptic contour charts of both limbs during successive Carrington rotations. An example is shown in Figure 3. Such charts permit us to easily recognize large scale rearrangements and evolution of the corona on long time scales and to perform the following studies.

(i) Study and identify the long term changes in the global coronal structure that take place due to the occurrence of transients.

(ii) Follow the evolution of coronal holes for long periods of time, at several heights corresponding to different frequencies.

ACKNOWLEDGEMENTS.

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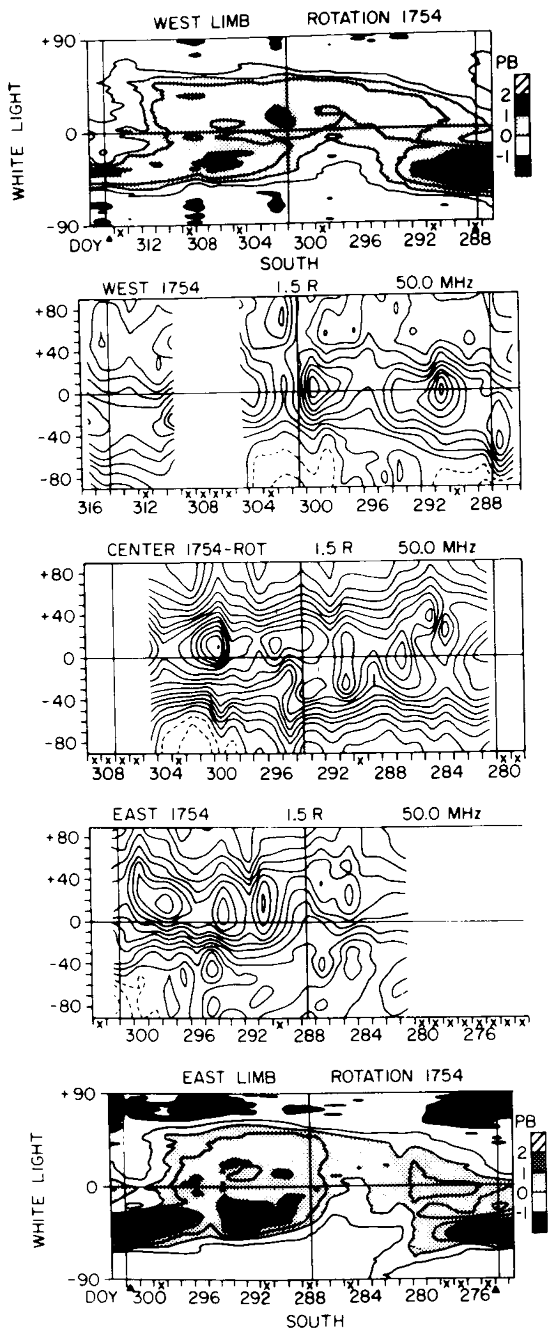

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Figure 3. Synoptic charts from 50 MHz map data at (b) West limb, (c) Central Meridian, (d) East limb, at radius 1.3 $R_\odot$. Mauna Loa coronagraph synoptic charts made from west and east limb data are shown in (a) and (e). There is a general correspondence between the maxima of the 50 MHz west limb charts and the brighter regions of the white light west limb charts, although the maxima do not have a one-to-one association. The coronal hole at the south pole is apparent in both the 50 MHz and white light data.

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