CORONAL ACTIVITY AND INTERPLANETARY DISTURBANCES

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CORONAL ACTIVITY AT RADIO WAVELENGTHS

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ABSTRACT We describe the multifrequency radioheliograph of the Clark Lake Radio Observatory. Its use for studies of large scale structures of the corona at long radio wavelengths is discussed. We show that features corresponding to coronal streamers and coronal holes are readily apparent in the Clark Lake maps. We also present results on studies of microbursts at meter-Decameter wavelengths.

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, and on microbursts at meter-decameter wavelengths.

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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 several CLRO 50 MHz maps superposed on coronagraph images acquired by the NRL SOLWIND coronagraph. The coronagraph images cover the middle to outer corona (2.5-10 $R_\odot$) and show the polarization times brightness product (pB) (Sheeley et al

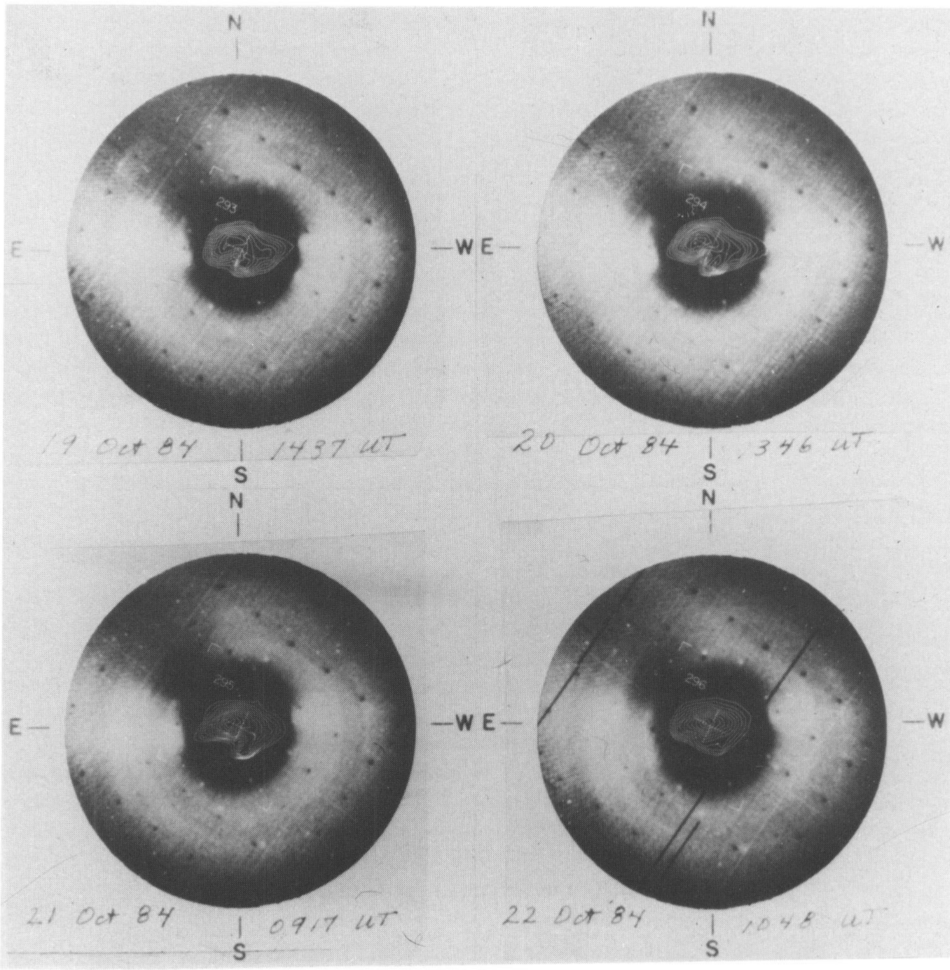

Figure 1. 50 MHz maps superposed on SOLWIND coronagraph images. One of the best 50 MHz/streamer associations is shown in the image of October 19, where a streamer extends out to several solar radii at PA-270 degrees. Coronal holes are seen in all images except that of October 19, 1984.

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1980). 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.

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 2. 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.

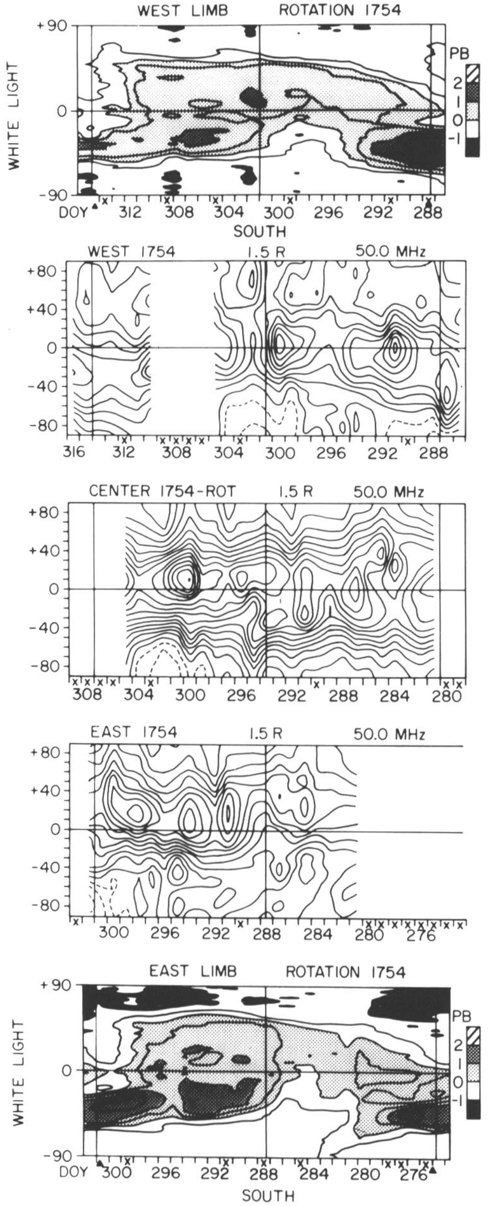

Figure 2. Synoptic charts from 50 MHz map data at (b) West limb, (c) Central Meridian, (d) East limb, at radius 1.3 $R_{\odot}$. Mauna Loa coronagraph synoptic charts made from west and east limb data are shown in (a) and (e). There is a general correspondence between the maxima of the 50 MHz west limb 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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2. Microbursts at Meter-Decameter Wavelengths

With the CLRO radioheliograph we have been recording with a time resolution of 0.6 sec many weak microbursts of unknown spectral type, lasting from a few seconds to 10-20 seconds. From the imaging observations we find that these bursts originate from one or two specific active regions rather than from all over the Sun (Fig. 3); the positions of these microbursts at meter-decameter wavelengths do not change over their duration, implying that they must be due to plasma

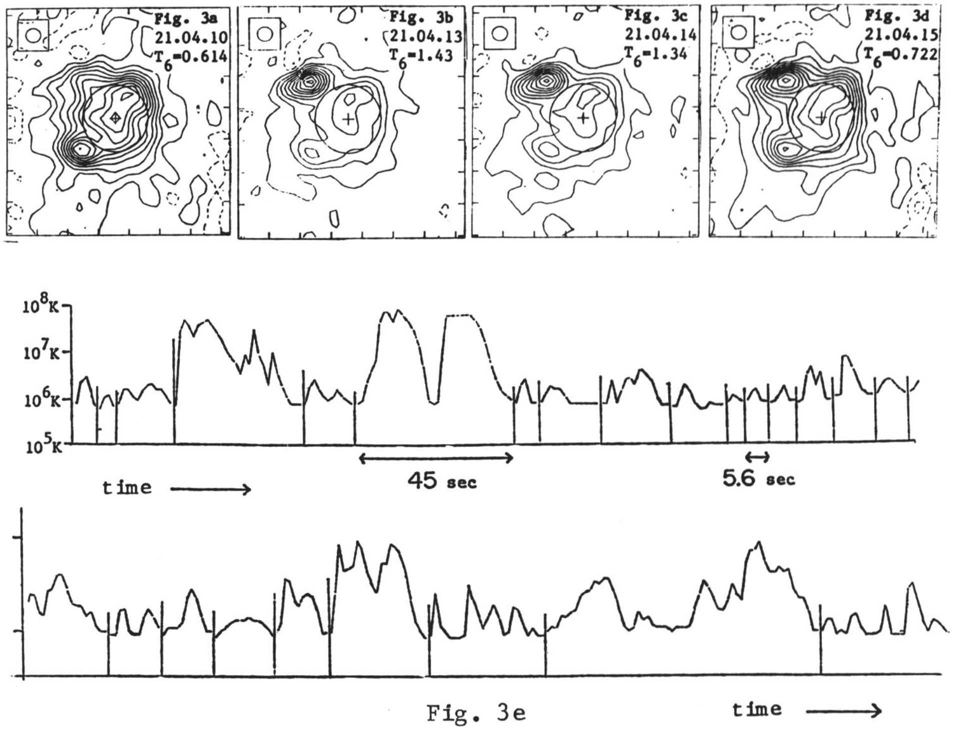

Fig. 3e

Figure 3. (a),(b),(c),(d) Clark Lake maps of a microburst observed at 50 MHz on March 23, 1985. The labels indicate the figure number, the universal time and the peak brightness temperataure in units of 10^6 K. The maps are made consecutively, 1.4 seconds apart. The contour levels are linearly spaced with a separation which is 10% of the peak brightness temperature. Tick marks on the vertical axis are separated by 15 arcmin, while those on the horizontal axis represent 1 minute of RA. (e) a compilation of the peak brightness temperature measurements of the sun at 50 MHz as a function of time for the period during which microbursts occurred on March 23, 1985. Breaks in the record are indicated by vertical lines. Consecutive points are 1.4 seconds apart; the vertical scale is logarithmic. The instrument saturates for brightness temperatures above 10^8 K.

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radiation (Kundu and Stone 1984). Thus, our results seem to suggest that we are dealing with nonthermal electrons. It remains to be seen if these nonthermal electrons are released/accelerated at the same time as the nonthermal electrons responsible for the hard X-ray microbursts observed by Lin et al (1984).

Figure 4 shows maps produced sequentially at three frequencies, 38.5, 50.0 and 73.8 MHz, with a cycling time of ~ 5 seconds and 1.28 sec integration time. It is clear from Figure 4 that the burst peaks later at the lower frequencies.

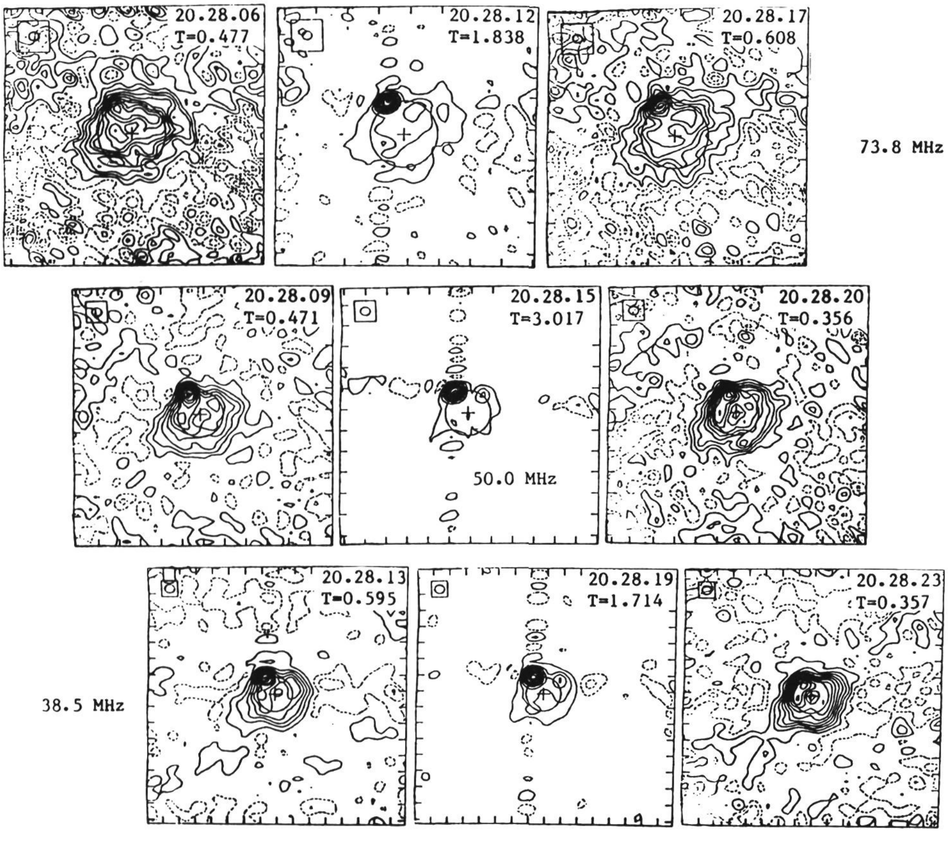

Figure 4. Clark Lake maps showing the evolution of a microburst (August 15, 1985) at three frequencies. The maps on the top line are at 73.8 MHz. The time of each map and the maximum brightness temperature (in units of 10^6 K) are indicated in the inset in the upper right corner. The maps on the middle line are at 50.0 MHz, and those on the bottom line are at 38.5 MHz. Time proceeds from left to right. The maps were made by multiplexing sequentially through four frequencies, but the fourth frequency (57.5 MHz) was contaminated by interference.

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The stationary character of microbursts at a particular frequency suggests that they are due to plasma emission from the layer in the corona in which ω_p, or possibly $2\omega_p$, equals the observing frequency. The occurrence of similar bursts at a wide range of frequencies, corresponding to high altitudes in the corona, at around the same time suggests that they are type-III-like in nature, rather than, e.g., type-I-like. The data shown in Figure 4 lend strong support to this interpretation. They are consistent with an electron stream propagating out through the corona, exciting Langmuir waves at lower frequencies as it reaches higher altitudes. From the time delay in Fig. 4 we find a velocity of about 6 10^9 cm^{-1}; however the data could be consistent with any speed between 0.1c and c. The drift speed is thus comparable to the typical speeds of type III bursts. Detailed theoretical considerations (White et al 1985) suggest that microbursts are due to plasma emission at the fundamental plasma frequency.

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