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# DECAMETER WAVELENGTH OBSERVATIONS OF AN ABSORPTION BURST FROM THE SUN AND ITS ASSOCIATION WITH AN X2.0/3B FLARE AND THE ONSET OF A "HALO" CORONAL MASS EJECTION

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## ABSTRACT

We report a transient intensity reduction/absorption burst observed at decameter wavelengths in close temporal association with an X2.0/3B flare near the disk center and the onset of a "halo" coronal mass ejection. The observed bandwidth of the burst was about 10 MHz. The size of the absorption region was estimated to be ≈28,000 km.

*Subject headings:* solar-terrestrial relations — Sun: activity — Sun: corona — Sun: flares — Sun: radio radiation

## 1. INTRODUCTION

There have been several reports on the presence of short-lived, narrowband absorption events in the solar radio spectra obtained at meter to decameter wavelengths in the literature (Boischot & Fokker 1959; Aller, Jensen, & Malville 1966; Slottje 1972; Zaitsev & Stepanov 1975; Sastry, Subramanian, & Krishan 1983). The features are generally weak, and their observed characteristics sometimes resemble those of type III radio bursts (Wild, Smerd, & Weiss 1963). In view of this, they are also called "shadow" type III events (Kai 1973). However, a correspondence between the observed radio events and the associated solar surface activity has not been reported so far. Such a study is expected to be useful in understanding the coronal processes associated with eruptive flares, coronal mass ejections (CMEs), and global coronal waves. In this Letter, we report decameter wavelength observations of a transient absorption burst that was temporally associated with an X2.0/3B flare and the onset of a "halo" CME.

## 2. OBSERVATIONS

The radio data reported were obtained on 2000 November 24 with the digital spectrometer operating at the Gauribidanur radio observatory near Bangalore in India (see Ebenezer et al. 2001 for details on the instrument). Figure 1 shows the time profile obtained with the spectrometer at 50, 55, 60, and 65 MHz, in the interval 04:45–05:30 UT. One can clearly notice several transient emission events, starting from 04:58 UT, at all four frequencies. At 05:08 UT, a sudden reduction in intensity was observed at 55 MHz, and it lasted until 05:10 UT. The fall in the flux density was about 0.2 sfu (1 sfu = solar flux unit = $10^{-22}$ W m$^{-2}$ Hz$^{-1}$). The absorption event was again followed by emission up to 05:17 UT. The time profile obtained at 60 MHz also showed a similar behavior. However, the intensity of the absorption feature was less compared to that at 55 MHz and was almost at the limit of detection. The situation at 50 MHz was the same. In fact, one could notice emission features also in the time profile obtained at the latter frequency around the same period. The absorption was completely absent above 60 MHz (see the 65 MHz time profile in Fig. 1). Also, the heliogram obtained with the Gauribidanur radioheliograph (Ramesh et al. 1998) at 109 MHz around the same time did not reveal any absorption feature. From the above, we assumed the bandwidth of the event to be ∼10 MHz. According to the CME catalog for the year 2000, the Large Angle Spectroscopic Coronagraph (LASCO; Brueckner et al. 1995) on board the *Solar and Heliospheric Observatory* (*SOHO*) observed a "halo" CME on 2000 November 24, at 05:30 UT, the time at which it was first noticed in the field of view of the LASCO C2 coronagraph. Figure 2 shows a "difference" image of the above event. The preevent reference image was obtained at 05:06 UT. The estimated speed of the CME was 1074 km s$^{-1}$ (Fig. 3). Prior to the CME, there was an X2.0/3B flare in the NOAA Active Region 9236 (N20°, W05°). The X-ray event started at 04:55 UT and lasted until 05:08 UT, with the peak at 05:02 UT (Fig. 4). This suggests that the absorption burst occurred during the postmaximum phase of the flare. From the height-time plot in Figure 3, one can notice that the onset of the CME also took place around the same period. The flare event was also accompanied by type II radio bursts with an estimated shock speed of 1000 km s$^{-1}$.[1] It is to be noted here that the above active region gave rise to two more X-class flares later in the day. They were also associated with "halo" CMEs like in the present case.

## 3. ANALYSIS AND RESULTS

The transient intensity reduction(s) observed in the decameter wavelength range are generally ascribed to absorption by ion-sound turbulence, generated by a shock wave (Melrose 1974b; Fokker 1982; Gopalswamy, Thejappa, & Sastry 1983). Therefore, it is possible that the absorption burst observed in the present case might be due to coronal shock waves from the reported X2.0/3B flare. The reported observations of type II radio bursts also suggest this. The short duration of the absorption event is probably due to the damping of the ion-sound turbulence below a critical level (Gopalswamy et al. 1983). Although free-free absorption by the dense prominence material overlying a flare site has been suggested as a possibility for similar events observed in the past in the centimeter wavelength range (Covington & Dodson 1953), it might not apply here because of the narrow bandwidth of the event reported. According to Melrose (1974a), the thickness $L$ of the region of intensity reduction is given by

$$L = BL_n, \tag{1}$$

[1] See http://www.sel.noaa.gov.

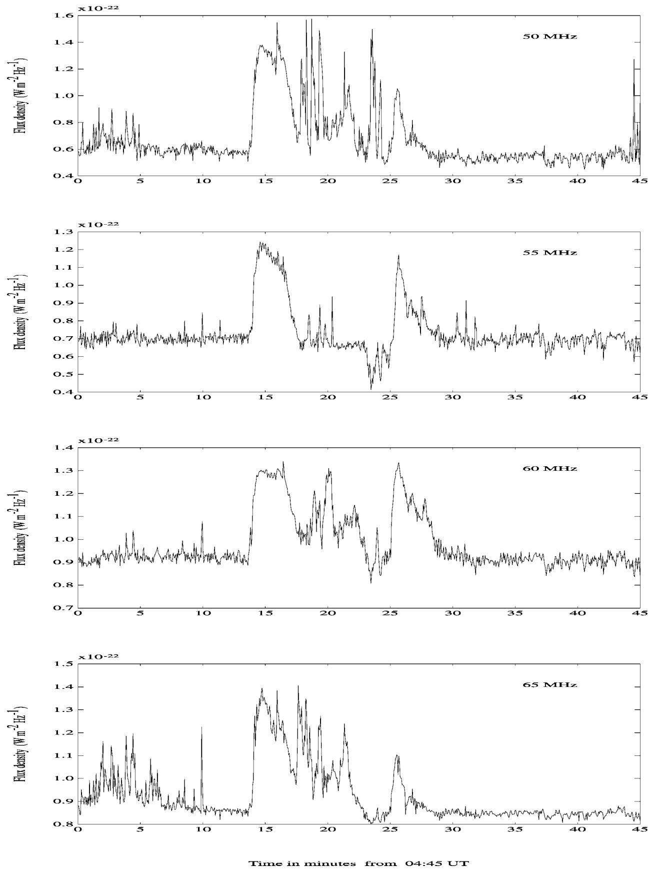


FIG. 1.—Time profile of the emission/absorption burst(s) observed on 2000 November 24 at four different frequencies (50, 55, 60, and 65 MHz) in the time interval 04:45–05:30 UT.

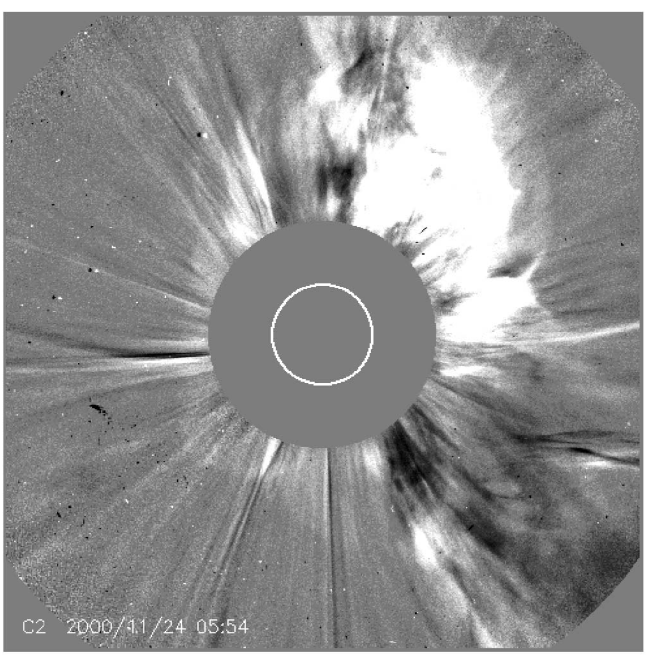


FIG. 2.—Difference image (05:54–05:06 UT) of the "halo" CME observed on 2000 November 24 with the LASCO C2 coronagraph on board *SOHO*. The inner circle indicates the solar disk, and the outer circle is the occulter of the coronagraph. It extends approximately up to 2.2 $R_\odot$ from the center of the Sun. Solar north is straight up, and east is to the left.

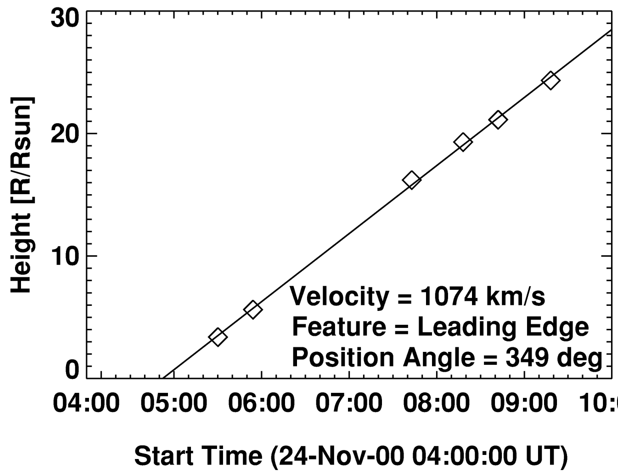


FIG. 3.—Height-time plot of the "halo" CME in Fig. 2. The diamonds mark observations with LASCO C2 and C3 coronagraphs, while the straight line is a linear fit to the data. The speed of the CME was measured by following its leading edge as a function of time.

where $B$ is the fractional bandwidth of absorption (~0.18 in the present case) and $L_n$ is the scale height of the coronal electron density variation. We calculated the latter using Newkirk's model (Newkirk 1961), and its value corresponding to the 55 MHz plasma level (located at a distance of 1.48 $R_\odot$ [$R_\odot = 1$ solar radius $= 6.96 \times 10^5$ km] from the center of the Sun) is $\approx 0.22\ R_\odot$. Substituting the different values in equation (1), we get $L = 0.04\ R_\odot$. We also calculated the brightness temperature ($T_b$) corresponding to the reduction in the observed flux density, and the value is $\approx 6.22 \times 10^8$ K. This agrees closely with that for a similar absorption burst reported earlier by Kai (1973). The event was observed against a background type II emission indicating the presence of shock waves as in the present case. It must be pointed out that the Newkirk's model used here applies to "quiet" corona in the equatorial region. We have a dynamic situation here involving a CME that can substantially alter the coronal conditions, and hence the above derived values must be treated with caution.

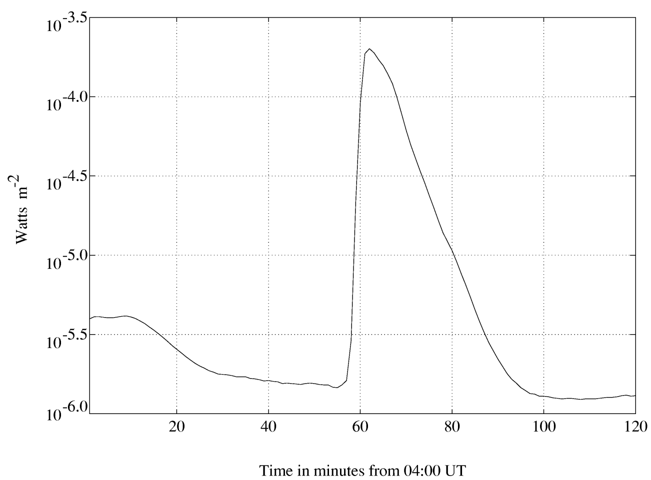


FIG. 4.—*GOES 8* X-ray light curve (1 minute average) during the time interval 04:00–06:00 UT on 2000 November 24.

## 4. CONCLUSIONS

We observed a transient intensity reduction at decameter wavelengths in close temporal association with the "halo" CME and X2.0/3B flare observed on 2000 November 24, around 05:00 UT. The main conclusions are as follows:

1. There is a close temporal association between the absorption burst event noticed in our observations and the X2.0/3B flare and onset of the "halo" CME reported.
2. The coronal shock waves give rise to absorption bursts at decameter wavelengths under favorable conditions.

It is suggested that further observations of this type might be useful, particularly in connection with the study of energetic events in the solar atmosphere since radio data can be obtained with a high time resolution.

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