# TEMPORAL AND SPECTRAL INVESTIGATION OF TWO THERMAL IMPULSIVE MICROWAVE AND X-RAY BURSTS OF 1972 MAY 18 FOR THE DETERMINATION OF SOURCE PARAMETERS

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Summary. In order to study the dynamical burst process we investigated two bursts of 1972 May 18 at 14:05 UT and at 16:16 UT in the microwave (1-15 GHz, Berne and Sagamore Hill), the hard X-ray (28-102 keV, ESRO TD-1A) and the soft X-ray (0.5-20Å, Solrad 11) frequency ranges. For both flares a thermal interpretation was adopted.

From the hard X-ray spectrum the plasma temperature T and the emission measure EM can be calculated (Mätzler et al. 1978). For these two bursts the temperature varied between 60 and 200 million $^{o}$K during the impulsive phase. Such high temperatures keep the microwave source optically thick up to high harmonics of the gyrofrequency (Drummond and Rosenbluth, 1963). During the 14:05 UT event the peak frequency varied between 8.8 and 15.4 GHz, indicating that the burst source was situated in magnetic fields between 210 and 370 Gauss.
The peak frequency for the burst of 16:16 UT remaind constant at about 9 GHz allowing an investigation of the low and high frequency spectral index. The two indices are very well correlated throughout the entire duration of the event (Fig. 1). A low frequency spectral index of 2.0 is expected if the thermal source is sharply bounded and if selfabsorption occurs. Inhomogeneities in the source, which are mostly expected during the impulsive phase, decrease this value below 2.0 (Schöchlin and Magun, 1979).
The time of maximum radiation of the burst (Fig. 1) of 14:05 UT was first reached at 15.4 GHz and 8 sec later at 2.7 GHz. The delay for the burst of 16:16 UT between 15.4 and 5 GHz was 6 sec. This long delay rules out an explanation by an electron beam because the velocities involved are much too small.

The hard X-ray time profiles lead the 10.5 GHz burst signals by about 2 sec and occur simultaneously with the 15.4 GHz bursts. We conclude that the two hard X-ray bursts and the high frequency microwave bursts originated from the same low coronal regions and that the low frequency microwave bursts came from a higher coronal, less dense and cooler plasma.

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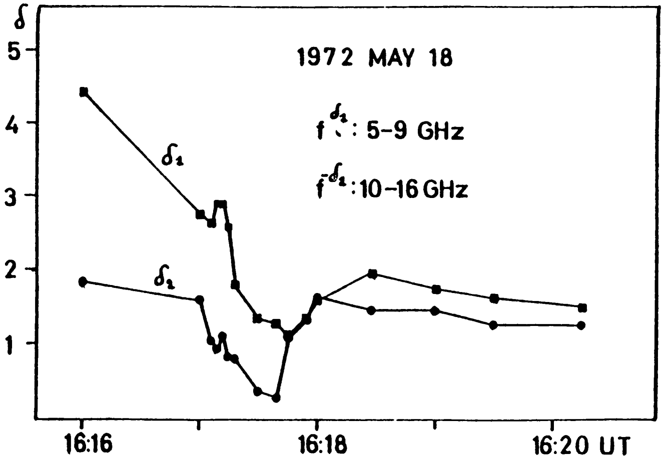

FIGURE 1. Time profiles of the low and high frequency spectral indices.

The correlation diagram (Fig. 2) between EM and T strongly indicates that the thermal source is expanding and thereby heating up previously cold surrounding plasma. This situation may be regarded as the quasi-steady propagation of energy from the hot region into the cold plasma by a collisionless conduction front (Brown et al. 1979) travelling through the plasma at the ion-sound speed.

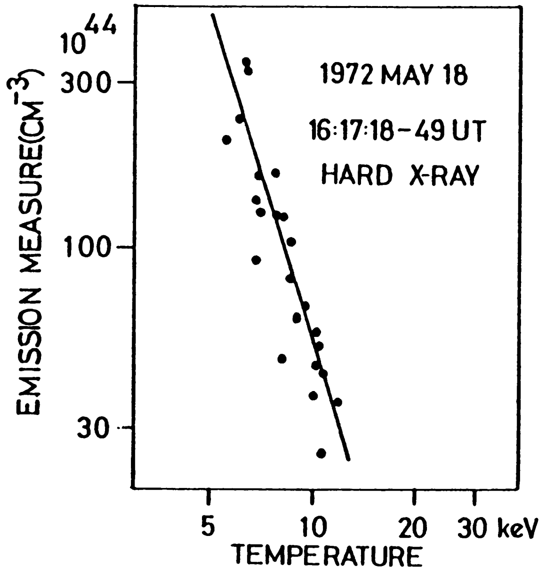

FIGURE 2. Correlation diagram between emission measure and temperature. The solid line represents EM $\propto T^{-3,2}$.

The soft-X-ray EM increased by about three orders of magnitude while the soft-X-ray temperatures dropped to about 5-10 % of their hard X-ray values in the course of a few minutes, further supporting the model of an expanding source.

For temperatures of $10^8$ - $10^9$ °K the peak frequency, the microwave flux in the Rayleigh-Jeans approcimation and the emission measure can be calculated as functions of temperature, magnetic field, emission areas and electron density (Dulk et al. 1978).

By measuring the first quantities for these two events the latter three can be computed. The result of these calculations show that the two bursts occured in a diverging magnetic field configuration with an upward decreasing electron density.

The rise time of a burst is determined by the ratio of characteristic length and Alfvén speed, whereas the fall time is determined by the time it takes the collisionless conduction front to sweep out enough plasma in order to cool the hot region. The ratio of rise to fall time is therefore given by the plasma beta. For the 16:16 UT event $\beta = 0.13$ at 15.4 GHz.

These bursts are an ordinary type observed in Berne representing some 20 % of all events recorded. The physical processes discussed should be quite common in solar flares.

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## DISCUSSION

Vlahos: Could you explain why the energetic electrons which drive the unstable return current don't leave any signature? These electrons have $E \sim 150$ keV and they have large densities $\gtrsim 10^7$ cm$^{-3}$. These electrons must give 10-100 times more flux than the truncated Maxwellian in the conduction front.

Wiehl: There is a peculiar peak during the rise phase of the burst of 16:16 UT, seen only at 217 GHz. During the burst at 14:05 UT no such features were observed at any frequency. Drs. D. Smith and J. Brown are presently working on the problem of the escape of electrons.

D. Smith: In the Brown, Melrose and Spicer paper, the ion-acoustic waves were assumed to be isotropic. We know from theory, experiment and simulation that current-driven ion-acoustic turbulence is confined to an opening angle of about 45° around the direction of the current. The number of escaping particles must be calculated taking this into account. Dr. Brown and I are now doing this.

Spicer: You have assumed that the rise time of the burst was given by $L/V_A$, while the fall time was given by $L/C_s$, where L is the characteristic scale length parallel to $\underline{B}$ and $V_A$ and $C_s$ are the Alfvén velocity and the ion sound velocity, respectively. However, the rise time could have been $\ell/V_A$, where $\ell$ is the characteristic field scale length perpendicular to $\underline{B}$. Hence your result could have been

$$B = \left(\frac{L}{\ell}\ \frac{t_{rise}}{t_{fall}}\right)^2$$

Wiehl: We assumed that in the burst source at 15.4 GHz the horizontal and vertical dimensions are still about equal. The divergence starts somewhat higher. The ratio of rise to fall time is, however, frequency dependent.