AN OBSERVED CORRELATION BETWEEN THE FLUX DENSITIES OF EXTENDED HARD X-RAY AND MICROWAVE SOLAR BURSTS

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Crannell et al. (1978) have reported an observed correlation between the time profiles and flux densities of impulsive hard x-ray and microwave solar bursts. We report here on a significant correlation between the fluxes of extended bursts of hard x-rays and microwaves. The significance of our observations follows from the suggestion of Wild, Smerd and Weiss (1963) that the extended bursts are evidence for a second phase acceleration process in the corona. We show that the observed characteristics of these extended microwave bursts (viz. rather a flat spectrum below a turnover frequency which is independent of intensity) can be explained by gyrosynchrotron radiation from the same population of energetic (E $\sim$ 100 keV) electrons as those emitting thin-target x-ray bremsstrahlung.

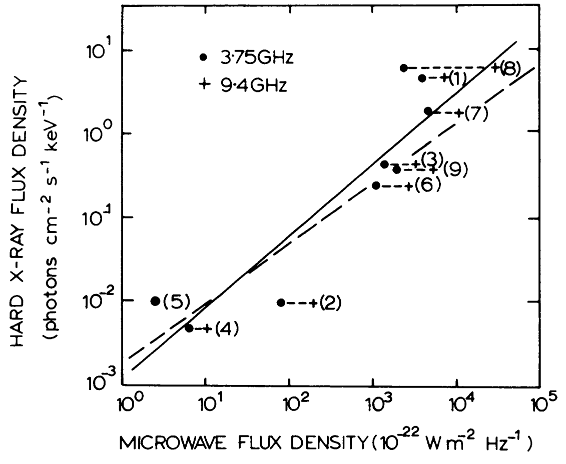


Figure 1. Observed correlation between hard x-ray and microwave flux densities near times of maxima in the 9 large solar flare (extended) events. Full lines show the least means square fit (logarithmic) to the 9.4 GHz and long dashed lines to the 3.75 GHz data.



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Figure 1 shows that a good correlation (correlation coefficient $r^2 \sim 0.8$) exists between the 100 keV x-ray and 3.75 or 9.4 GHz microwave flux densities near the time of x-ray maximum. The spectra have two important properties. Firstly, below the turnover frequency $f_m$ the spectrum is much flatter, i.e. $S \propto f^1$ (on the average) than that of impulsive bursts $S \propto f^2$ (Crannell et al. 1978). Secondly, although the flux varies by over three orders of magnitude (Fig. 1), the turnover frequency remains fairly constant. $10\ \text{GHz} \leq f_m \leq 20\ \text{GHz}$ in four of the nine events (Fig. 2) and $f_m \geq 10$ GHz in another four. The remaining event (No. 5 of Figs. 1 and 2) with $f_m \sim 1$ GHz can be explained by occultation effects.

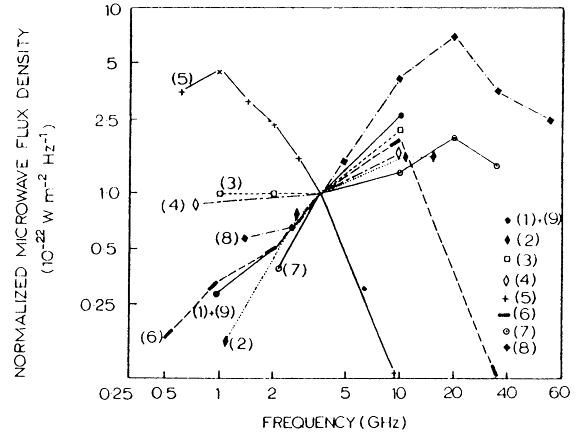


Figure 2. Normalized (to 3.75 GHz value) microwave spectra of the 9 extended solar bursts.

We take the view that a correlation between 100 keV hard x-ray and microwave flux densities means that both the x-ray and microwave emission come from the same population of energetic electrons in the corona. Takakura (1972) has suggested that the flat microwave bursts are produced when there is a non-uniform magnetic field distribution within the source region. We extend Takakura's argument to show that in a dipolar magnetic field, where $B \propto (1/R)^3$ and R is the distance from the dipole, the absorption coefficient for gyrosynchrotron radiation K varies as something like $(1/R)^{12}$. We find that the emission comes from very thin shells which occur at increasing heights for decreasing frequencies. With this model we can explain both the constancy of the turnover frequency with changes in flux and also the flatness of the observed spectrum. Moreover, the model requires a similar number of energetic electrons for both the hard x-ray and the microwave bursts thus confirming our original hypothesis that the x-ray and microwave emissions during extended solar bursts emanate from the same population of energetic electrons situated low in the corona.

## References

Crannell, C. J., Frost, K. J., Mätzler, C., Ohki, K. and Saba, J. L.: 1978, *Astrophys. J.* 223, 620.

Takakura, T.: 1972, *Solar Phys.* 26, 151.
Wild, J. P., Smerd, S. F. and Weiss, A. A.: 1963, *Ann. Rev. Astr. Astrophys.* 1, 291.

## DISCUSSION

Kawabata: In our observations of about 100 bursts other than GRF, peak flux densities at 8.6 mm are always less than the peak flux densities at 3 cm. The ratio of the flux densities at 3 cm and 8.6 mm, $F_{3cm}/F_{8.6mm}$, is typically 3.

Stewart: The turnover is somewhere around 15 GHz, it appears. I think that this suggests that there is a maximum magnetic field strength in the corona during these big flares, and is given by the turnover frequency. Everything above it is either optically thin or has some thermal component.

Karpen: The March 30 and March 1 events, which you show spectra for, also were behind-the-limb events. Why don't these events exhibit peculiar spectra like the July 22 event?

Stewart: I don't know why the 1969 March 30 event is different from the 1972 July 22 except that it had an expanding source structure at microwaves and a very impulsive phase. Perhaps it was closer to the limb?