Microwave, Hα and Hard X-ray Observations of the 1992 June 26 C7.3 Solar Flare

Haimin Wang

Big Bear Solar Observatory, Caltech, Pasadena, CA91125, USA

(Extended Abstract)

Studying of solar microwave and hard X-ray is important in understanding the electron accelerations in the flare process. High temporal, spatial and spectral resolutions are vital for radio observations. In the past, microwave flares on the Sun have been studied with multi-frequency but with little or no two dimensional spatial information, (Stahli, Gary and Hurford, 1989, 1990; Wiehl et al., 1985), or high spatial resolution but little or no spectral information (e.g. VLA observation by Marsh & Hurford 1980). Since bursts may be composed of multiple sources, the spectrum obtained with poor spatial resolution may be a composition of multiple sources. On the other hand, the microwave maps may vary markedly with frequency (Dulk, Bastian & Kane, 1986), so high spatial resolution observation without spectral information could not interpret radiation mechanism. Starting from June 1991, the Owens Valley Radio Observatory (OVRO) upgraded its solar array to the 5-element array. This improved its ability to obtain high spatial (5" to 20") and spectral (45 frequencies from 1 to 18 GHz) resolution with moderate time resolution (6-12s) (Lim et al., 1993). The electrons that produced hard X-ray emissions in solar flare have long be considered as the same group which are responsible for the microwave bursts (Dennis, 1988). However, most observations of the solar flare hard X-ray have been obtained with instruments of modest or poor spectral resolution (Dennis and Schwartz 1989). The launch of the Compton Gamma Ray Observatory has make available high quality solar flare observations since April of 1991. In particular, the Burst and Transient Source Experiment (BATSE) offers dramatic a increase in sensitivity and excellent energy resolution about 10keV (Schwartz et al., 1993).

In this paper we compare the optical, microwave and BATSE observations of the June 26, 1992 C7.3 flare that occurred at 1710UT. Hα movies were obtained at Big Bear Solar Observatory. Before the onset of the flare, over-exposed Hα images show the complicated flux loop structure above the limb. Material is observed to descend along the loops towards the site where the flare occurred hours later. Using the 5-Antenna solar array at Owens Valley Radio Observatory, we obtain two dimensional maps of flare emission from 1.4 to 14 GHz. In all three temporal peaks of the microwave bursts, the maps show the same characteristics. The low frequency emission comes from the top of one bundle of the Hα loops and gradually shifts to the footpoint of the loops (the location of Hα flare) as the frequency increases. The locus of the shift of the emission peak follows the shape of an Hα surge that occurred after the flare. For each point along the locus, we create the microwave brightness temperature spectra, and compare radio derived electron distribution with that derived from the high resolution hard X-ray spectra observed by the BATSE on board the Compton Observatory. We found that the peak frequency increases as we move from loop top to the footpoint, meaning that the magnetic field increases towards the footpoint; and the high frequency slope of microwave spectra gets harder from the loop top to foot point. The microwave brightness temperature index predicted by the BATSE power-law hard X-ray spectra agrees with the observation only at the footpoint. At the loop top, the emission may be due to thermal gyrosynchrotron with a temperature of 3.5×10^7 K.

FIGURE 1

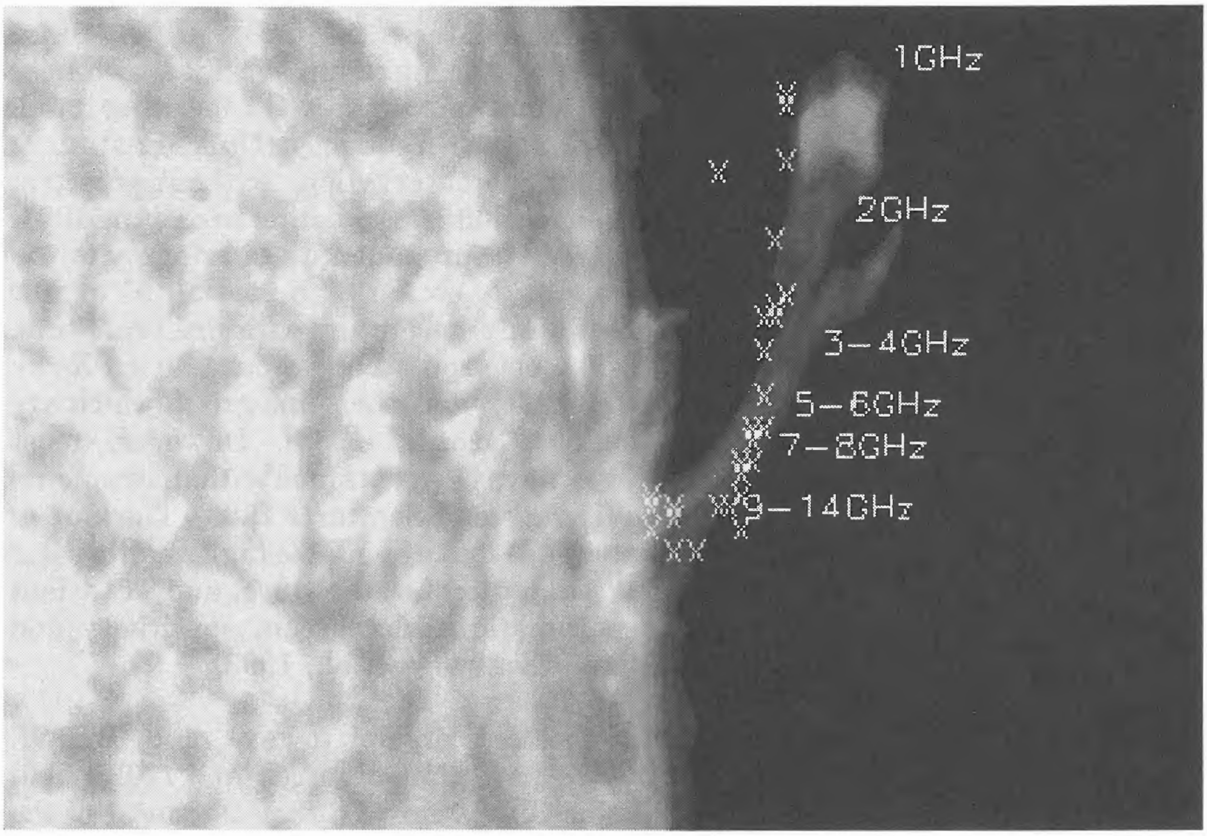
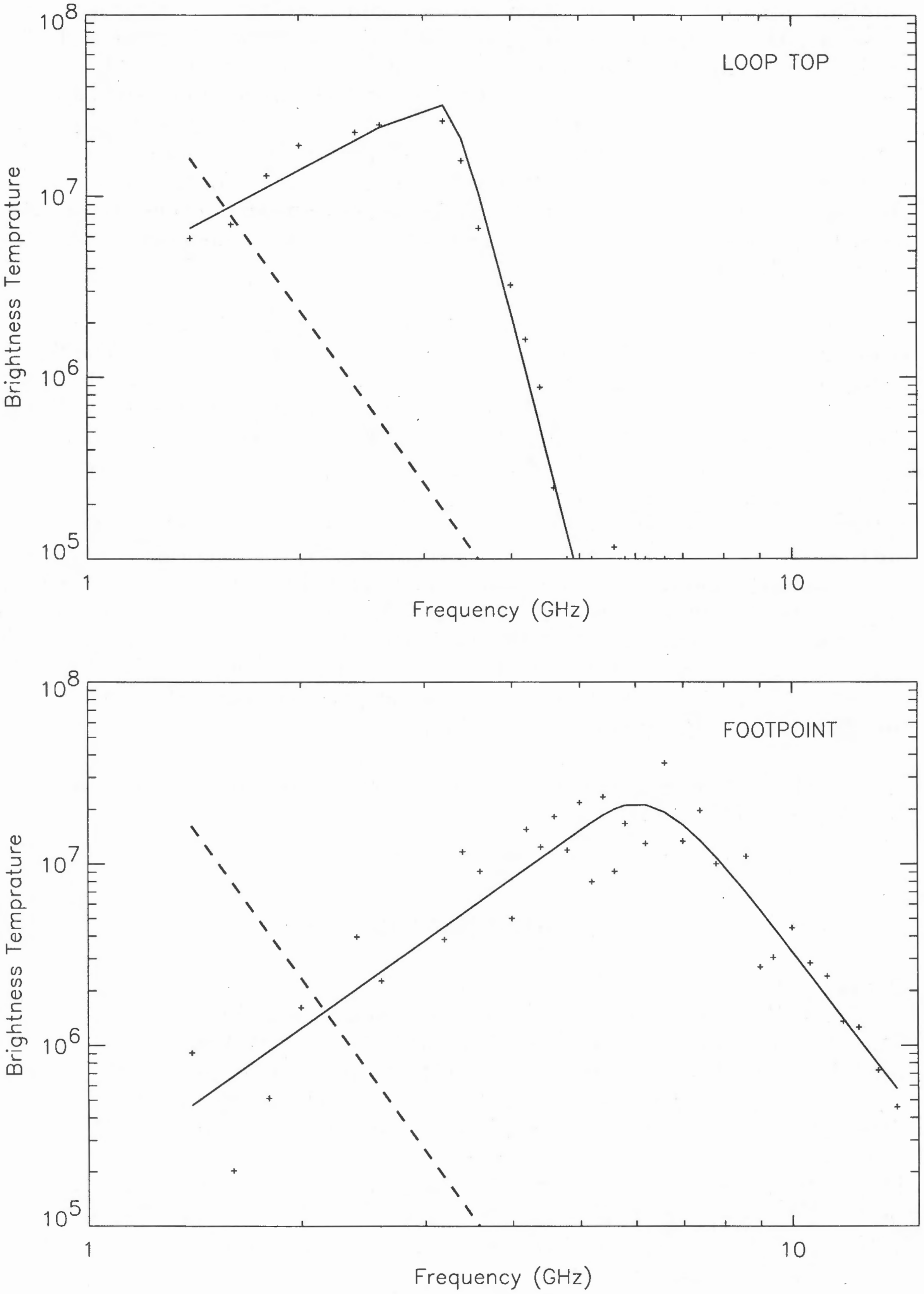


Figure 1 shows the positions of emission peaks of radio maps. The field of view of the image is 220 by 150 arcsec. The background is the Hα-0.5Å filtergram taken at 1730UT, 20 minutes after the radio bursts. The surge is clearly presented in the map. Please note that at the time of surge, there is no

FIGURE 2


LOOP TOP
Brightness Temprature
10^8
10^7
10^6
10^5
1
10
Frequency (GHz)
FOOTPOINT
Brightness Temprature
10^8
10^7
10^6
10^5
1
10
Frequency (GHz)

detectable microwave emission. So we are comparing two observations at different times. We show this comparison because we believe that the surge makes visible a magnetic structure that did exist during the impulsive phase of the flare. The emission peak shifts mainly towards South and sightly towards East for about 100 arcsec from 1 to 14 GHz. Most of the shift occurs between 1 and 5 GHz. The locus of the emission peaks follows the shape of the Hα surge. Likely, high energy electrons are trapped in the flux loops where the surge occurred minutes later. Low-frequency microwave emission comes from the top of the surge loop, and high-frequency emission comes from the footpoint, where the Hα brightening occurred simultaneously with the microwave bursts at 1710UT.

Figure 2a and 2b give a closer look of two typical radio brightness temperature spectra at the loop top and the footpoint respectively. The light solid line is the least-square fit of the observed spectra, developed by Stahli et al. (1989). The fitting gives peak brightness temperature, low-frequency slope, high frequency slope and turn-over frequency. Two dark dashed lines in Figure 2 reflect the predicted power index from the BATSE hard X-ray power index (photon index=3.9), assuming the radio emission is due to the power-law gyrosynchrotron. At the footpoint, the hard X-ray prediction matches with the microwave emission quite well. It is conceivable that the microwave emission from footpoint (mainly from the high frequency) and the hard X-ray emission are due to the same group of electrons. At the loop top, the brightness temperature spectra match with the shape of thermal gyrosynchrotron emission which requires the high frequency power index to be 10 and temperature to be 3.5×10^7 K, which is the temperature of a super-hot component observed by the BATSE spectra.

This work was done while the author was a Compton fellow under the NASA grant NAG5-2090.

REFERENCES

Dennis, B.R., 1988, Solar Physics, 118, 49
Dennis, B.R. & Schwartz, R.A. 1989 Solar Physics, 121, 75
Dulk, G.A., Bastian, T.S. & Kane, S.R. 1986, Ap. J., 300, 438
Lim, J., Gary, D.E. & Hurford, G.J., 1993, submitted to Ap. J.
Marsh, K.A. & Hurford, G.J., 1980, Ap.J. 240, L111
Schwartz, R.A., Fishman, G., Meegan, C., Wilson, R. & Paciesas, W., 1993, COSPA Proceedings
Stahli, M. Gary, D.E. & Hurford, G.J. 1989, Solar Physics, 120, 351
Stahli, M., Gary, D.E. & Hurford, G.J. 1990, Solar Physics, 125, 343
Wiehl, H.J., Batchelor, D.A., Crannell, C. J., Dennis, B.R. & Price, P.N., 1985, Solar Physics, 96, 339