Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

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Solar flares give us a unique opportunity to make spatially resolved observations to study magnetic energy release and particle acceleration in space plasmas. The most direct diagnostics of electron acceleration are provided through radio and hard X-ray observations where we observe synchrotron emissions in the GHz range and non-thermal bremsstrahlung emissions above typically 10 keV. The two leading solar dedicated observatories in these two wavelength ranges are the Nobeyama Radioheliograph (NoRH) and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI).
We present a statistical study of 35 jointly observed big (>GOES M7) flares. Initial results reveal a linear correlation between the hard X-ray flux above 50 keV and the microwave fluxes at 17 and 34 GHz. This result indicates that the population of accelerated electrons emit both of hard X-rays and microwaves. The correlation is too good even if this is true. Because the mechanism of these two emissions (hard X-rays and microwaves) are much different. Hard X-rays are emitted by Bremsstrahlung and its intensity simply depends on the flux of the accelerated electrons precipitating into the chromosphere in the case that the thick-target model is valid. However, microwaves emitted by gyro-synchrotron are a little complex. The microwave source is observed at different location for flare by flare, i.e. near the looptop, at the footpoint region, and in between them. Footpoint region has much stronger magnetic field than the looptop region. Gyro-synchrotron emission is very sensitive to magnetic field strength. Though the microwave intensity may strongly depend on the source location, however, microwave intensity without any selection by source location shows a very good correlation with hard X-rays. Another puzzle is the energy spectrum of accelerated electrons. Roughly speaking, 50 keV hard X-rays are manly emitted by below 100 keV electrons. On the other hand, 17GHz and 34GHz microwaves are typically emitted by ~1 MeV electrons (it depends on the magnetic field strength of the emitting region). Typically accelerated electrons show a power-law spectrum with the power-law index 3 –6. The power-law index is different in flare by flare. When the number of 100 keV electrons is fixed, the number of 1 MeV electrons changes in 3 order of magnitudes with the change of the power-law index from 3 to 6. The microwave intensity is proportional to the number of ~1 MeV electrons. So roughly thinking, the ratio between hard X-rays and microwave intensity easily change with the change of the power-law index. Without considering the spectral information, we choose the events. However, still there is a very good correlation. This is also a hard puzzle.
In order to understand this too good correlation between hard X-ray and microwave intensity, we need further analyses such as source location of hard X-ray and microwaves, hard X-ray spectrum, photospheric magnetic field at the footpoint region, location of the flare on the solar disc, and so on.

Keywords: solar flare, particle acceleration, radio, hard X-ray

