Microwave turn-over frequencies and emission temperatures for white-light solar flares

*Kosuke Tsuruda[1], Kyoko Watanabe[1], Satoshi Masuda[2], Säm Krucker[3]

1. National Defense Academy , 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. University of Applied Sciences Northwestern Switzerland, UC Berkeley

It is believed that the origin of white-light enhancement, which is usually associated with large solar flare, is accelerated non-thermal electrons. The relationship between emission measure and temperature of white-light flares (WLFs) supported the existence of strong magnetic field around the acceleration site (Watanabe et al., 2017). Although the field strength at the acceleration site cannot measure directly, it can be estimated by using the turn-over frequency of gyro-synchrotron emission in microwaves (Dulk 1985). Kitagawa (2015, master thesis) suggested the existence of strong magnetic field on WLFs because the turn-over frequencies of WLFs were higher than those of no white-light flares (NWLFs), by the microwave spectra observed with the Nobeyama Radio polarimeters (NoRP).

We performed a statistical analysis of microwave turn-over frequencies for >M3 class flares during the period from January 2011 to December 2017. We found 51 events which were simultaneously observed with white-light (*Hinode*/SOT and/or *SDO*/HMI) and microwave (NoRP), however, we couldn't find any difference in turn-over frequencies for WLF and NWLF. We thought this result might be due to the difference of the location (loop-top or foot-point) of the microwave source in each flare. Then we checked the location of microwave emission by comparing with images of *SDO*/AIA (193Å), Nobeyama Radio heliograph (NoRH, 17GHz), and/or RHESSI (30-80 keV). Finally we found 29 flares (WLF: 17 events, NWLF: 12 events) have a dominant microwave source around the loop-top. When we checked turn-over frequencies for these events, only 7 events (WLF: 4 events, NWLF: 3 events) have higher turn-over frequencies than 17 GHz, and no clear difference was found between WLF and NWLF. Because the turn-over frequency is determined by not only the field strength but also the electron density (Dulk 1985), we have to think about the variation of electron density for this study.
On the other hand, durations of flare were clearly differing in WLF and NWLF, and WLFs are well associated with impulsive flares (Watanabe et al., 2017). However, there are some impulsive flares that do not have any white-light enhancements. In order to check the effect of flare duration (impulsivity) for white-light emission, a statistical analysis of emission temperature for WLFs is one of the effective approaches. So we derive emission temperature from three-color continuum data of *Hinode*/SOT (red, green, and blue) for ~40 events (e.g. Watanabe et al., 2013; Kerr & Fletcher, 2014), and discuss the relationship with flare impulsivity.

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