IRIS, *Hinode*, *SDO*, and *RHESSI* Observations of a White Light are Produced Directly by Non-thermal Electrons

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Sometimes strong solar flares produce continuum enhancements as a photospheric response, which is termed a white light flare (WLF). Previous observations showed that the continuum enhancement in WLFs is well correlated with hard X-ray emission both spatially and temporally [1,2]. From the correlation, it has been thought that WLFs are produced by the transported energy from accelerated particles such as non-thermal electrons [3]. With recent high spatial resolution observations, WL emission has been reported even in weak flares [4]. The electron flux from these low energy events is not enough to penetrate and heat the photosphere directly. Therefore, other heating mechanisms have also been considered. For example, WL emission is produced by electrons that heat the chromosphere directly and the photosphere indirectly [5]. However, the true heating mechanism in the lower atmosphere remains unclear.

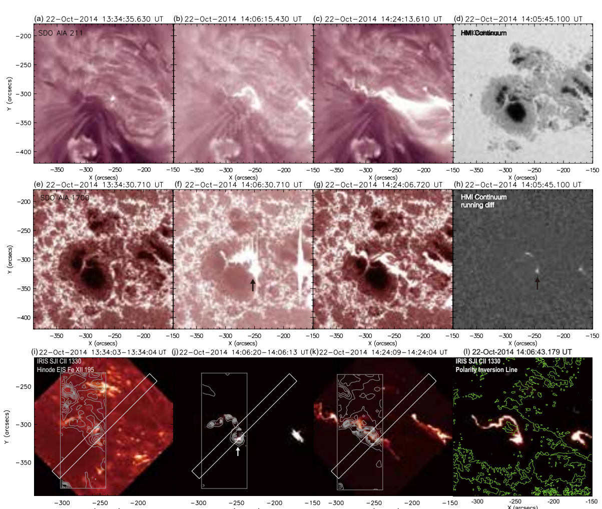

Figure 1: Context images for the X1.6 class flare. (a-c): AIA 211 Å, (e-g): AIA 1700 Å, (i-k): *IRIS* C II 1330 Å slit jaw images with EIS 195 Å intensity contours (gray line) before the flare, at the first HXR peak, and at the flare peak. (d, h): *SDO*/HMI continuum and a running difference image at HXR peak, respectively. (l): the polarity inversion line from the HMI magnetogram. The bright kernel we analyzed is marked with an arrow.

We have investigated An X1.6 flare occurred in AR 12192 on 2014 October 22 at 14:02 UT which was observed by several spectrometer in multi-wavelengths, *Hinode*, *IRIS*, *SDO*, and *RHESSI* (Figure 1). We analyze a bright kernel which produces a WLF with continuum enhancement and a HXR peak. Taking advantage of the spectroscopic observations of *IRIS* and *Hinode*/EIS, we measure the temporal variation of the plasma properties and dynamics in the bright kernel through chromosphere and corona. We found that explosive evaporation was observed when the WL emission occurred, even though the intensity enhancement in hotter lines is quite weak. The temporal correlation of the WL emission, HXR peak, and evaporation flows indicate that the WL emission was produced by accelerated electrons.

To understand the WL emission process, we calculated the energy flux deposited by non-thermal electrons observed by *RHESSI* and compared it to the dissipated energy estimated from a chromospheric line (Mg II triplet) observed by *IRIS*. The deposited energy flux from the non-thermal electrons is about $3 \sim 7.7 \times 10^{10}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ for a given low energy cut-off of $30 \sim 40$ keV, assuming the thick target model. The energy flux estimated from the temperature changes in the chromosphere measured using the Mg II subordinate line is about $4.6–6.7 \times 10^{9}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$: ~ 6–22 % of the deposited energy. This comparison of estimated energy fluxes implies that the continuum enhancement was directly produced by the non-thermal electrons.

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