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Thermal structures and plasma motions in plasma sheet of eruptive solar flares

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Solar flares are explosive phenomena that occur in the corona. They produce 10^7 K plasmas and non-thermal accelerated particles at the initial phase. Magnetic reconnection is considered to play an essential role in the flaring processes. The X-ray imaging observations by the *Yohkoh* satellite have revealed the structural changes at the flare site in detail. In addition to the structural evolutions, the discoveries of plasma blobs and high energy X-ray sources at the initial phase of flares have enabled us to believe that magnetic reconnection undoubtedly occurs in the corona. The next step for further understanding the physics of magnetic reconnection in solar flares is to do more quantitative evaluations of plasma dynamics in the reconnection region. The EUV Imaging Spectrometer (EIS)[1] on the *Hinode* satellite (left panel in Fig. 1) was developed to investigate the plasma property by remote-sensing spectroscopy.

EIS can obtain the line spectrum shown in Fig. 1b with the highest sensitivity in the extreme ultraviolet region. This instrument covers a wide temperature range, including multiple bright lines that can be observed simultaneously. However, since it is only one -dimensional data along the slit of the spectrometer that we can simultaneously obtain, a scanning operation of the image on the slit plane is required to get the EUV spectra at each point in the two-dimensional field. While the speed of the EIS scanning spectroscopy is not sufficiently fast for observing rapidly changing flare phenomena, it has become possible to know the instantaneous plasma state at each point. The intensity distributions in flare emission lines, which are obtained by such imaging spectroscopy, are shown in right panels in Figure 2. At each imaging point within these images, the line profile of EUV emission lines can be evaluated.

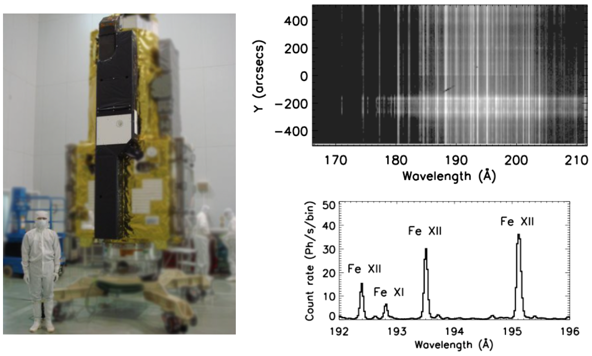

Fig. 1.: (Left) EUV Imaging Spectrometer (EIS) on the *Hinode* satellite. (Right-top) Full-frame spectral data obtained at one of the spectral bands and (right-bottom) a part of its horizontal cross section of the spectra.

In this presentation, I will focus on the research results obtained from line-spectral observations with EIS on the plasma sheet structure in eruptive-type solar flares[2,3,4,5]. The sheet structure is believed to appear above the loop-top regions as a result of magnetic reconnection. It is clear from the Doppler shift of emission lines formed at flare temperatures that the hot plasmas heated nearly up to the flare temperature are moving along this structure at high speed. Ion motions that significantly exceed the thermal velocity of electrons have been observed within the sheet. Bright structures in a turbulent state[5], with a higher temperature and enhanced density, have also been found at the top of the flare loop located ahead of the high-speed flow in the sheet. The properties of these observations are consistent with the flow structure expected from a fast magnetic reconnection process. I will also discuss fine-scale structures inside the plasma sheet and their motions inferred from the emission-line shape.

At the end of the presentation, I will briefly introduce the future spectroscopic satellite mission Solar-C, which has an improved resolution to investigate finer-scale dynamics and a shorter sampling interval in observations through improved sensitivity.

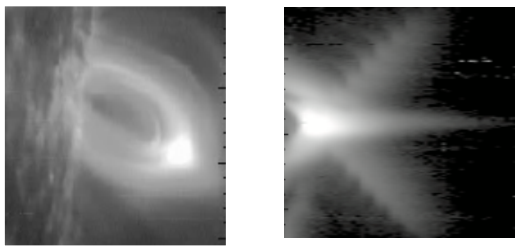

Fig.2: Examples of flare-loop structures in eruptive solar flares observed with EIS. Intensity maps of hot emission lines are shown. The emission-line profile is obtained at each imaging point.

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