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ひので EIS により観測されたフレア初期相における彩層蒸発速度の温度依存性
Chromospheric evaporation observed with Hinode/EIS: temperature dependent upflow in the impulsive phase

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The analysis of a chromospheric evaporation in a M-class flare observed with the EUV Imaging Spectrometer (EIS) onboard *Hinode* was conducted. We report for the first time the dependence on temperature of the chromospheric evaporation in the growing flare loops.

The solar flares are the most energetic phenomena in the solar atmosphere, which release the magnetic energy through magnetic reconnection. The coronal plasma is heated up to a few tens of MK in the slow shocks extended from the reconnection point. In that regime, thermal conduction becomes dominant, and the chromosphere at reconnected flare loops, dense and cool (T˜10^4K) plasma experiences impulsive heating by reaching thermal conduction front. The gas pressure of the heated chromosphere suddenly raises to around 10MK, which results in so called *chromospheric evaporation*, fast upflow along the flare loop with the sound speed (˜500 km s^{-1} at 10MK). This phenomenon has been firstly reported by Antonucci et al. (1982), in which the chromospheric evaporation was detected as the blueshifted component in the emission lines of highly ionized Ca XIX (mainly radiated by a few tens of MK). Although their data has very low spatial resolution, they revealed that the evaporation had occurred at the footpoints of flare loops by using other instruments. In the late 1990's, Czaykowska et al. (1999) firstly reported spatially resolved observation of chromospheric evaporation in the gradual phase observed with the Coronal Diagnostic Spectrometer (CDS) onboard the *Solar and Heliospheric Observatory* (*SOHO*), from which the authors reported relatively strong blueshift (˜100 km s^{-1}) of Fe XIX line profiles and the gradient in the Doppler velocity indicating the continuous reconnection. The chromospheric evaporation in the impulsive phase was also observed with *SOHO*/CDS as reported by Teriaca et al. (2003, 2006). They estimated the momentum balance of upflow in the corona and downflow in the transition region, resulting in the good agreement (in the order) which supports the evaporation scenario. Recent observation by *Hinode*/EIS has shown the existence of fast upflow up to 400 km s^{-1} in the Fe XXIII (˜10MK) line profiles at the footpoints of flare loops during the early phase of a flare (Watanabe et al. 2010). Fast upflows in the warm line (Fe XVI; 2-3MK) was also discovered in a small B class flare observed with *Hinode*/EIS (Del Zanna et al. 2011). However, the dependence of upflow velocity on temperature has not intensively studied yet.

In this study, we analyzed the ongoing chromospheric evaporation which occurred in the impulsive phase of a M1.2 class flare observed with *Hinode*/EIS on 2011 September 9. This flare had started soon after the filament erupted, followed by the formation of compact flare loops (L˜10,000km). Investigating the line profiles carefully, we found the enhanced blue wings in hot emission lines (Fe XXIII and Fe XXIV; a few tens of MK) which indicate the upflow from the solar surface of around 400 km s^{-1}. This value is slightly smaller than the sound speed at the temperature of 10MK (˜500 km s^{-1}), which supports the chromospheric evaporation scenario when considering the projection effect. Not only those hot emission lines, other coronal lines at the evaporation site also show the velocities near the sound speed in each formation temperature. The upflow is switched into downflow at several MK, and intriguingly, cooler lines ($\log T < 6.2$) show the downflow near the sound speed as same as the upflow. As a collateral evidence, the density derived by Fe XIV line ratio indicated the density of 10^{11} cm^{-3}, which also supports the evaporation from the dense chromosphere. Fortunately, the EIS spectroscopic slit cut across old and new flare loops simultaneously, which enables us to discuss the temporal evolution of the evaporation flow.

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