Non-thermal broadening of IRIS Fe XXI line caused by turbulent plasma flows in the magnetic reconnection region during solar eruptions

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Magnetic reconnection is the key mechanism for energy release in solar eruptions, where the high-temperature emission is the primary diagnostic for investigating plasma properties during the reconnection process. Non-thermal broadening of high-temperature lines has been observed in both the reconnection current sheet (CS) and flare loop-top regions by (E)UV spectrometers, but its origin remains unclear. In this study, we used a three-dimensional magnetohydrodynamic (MHD) simulation to model magnetic reconnection in solar flares and to reveal highly dynamic plasma flows in the reconnection regions. We calculated synthetic profiles of the Fe XXI 1354 Å line observed by the Interface Region Imaging Spectrograph (IRIS) spacecraft using the MHD results. Our model shows that turbulent bulk plasma flows in the CS and flare loop-top regions are responsible for the non-thermal broadening of the Fe XXI emission line, with modeled non-thermal velocity ranging from tens of km/s to over two hundred km/s, consistent with IRIS observations. Simulated two-dimensional spectral line maps around the reconnection region also reveal highly dynamic downward flow structures where high non-thermal velocity is large, which is also consistent with the observations.