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The Spatial and Temporal Variations of Turbulence in a Solar Flare

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MHD plasma turbulence is believed to play a vital role in the production of energetic electrons during solar flares and non-thermal broadening of spectral lines is a key sign of this turbulence. Here, we determine how flare turbulence evolves in time and in space using spectral profiles of Fe xxiv, Fe xxiii and Fe xvi, observed by Hinode/EIS. Maps of non-thermal velocity are created for times covering the X-ray rise, peak, and decay. For the first time, the creation of kinetic energy density maps reveal where energy is available for electron energisation, suggesting that similar levels of energy may be available to heat and/or accelerate electrons in large regions of the flare. We find that turbulence is not localised in the loop apex but distributed throughout the entire flare; often greatest in the coronal loop tops, and decaying at different rates at various locations in the flare. For hotter ions (Fe xxiv and Fe xxiii), non-thermal velocity decreases as the flare evolves and after the X-ray peak, showing clear spatial variation decreasing linearly from the loop apex towards the ribbon. For the cooler ion, the non-thermal velocity remains relativity constant throughout the flare, but steeply increases in one region corresponding to the southern ribbon, peaking just prior to the peak in hard X-rays before declining. The results suggest that the turbulence has a more complex temporal and spatial structure than previously assumed, while the newly introduced turbulent kinetic energy maps help to identify important spatial inhomogeneities in the plasma motions.

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