Large-scale particle acceleration during magnetic reconnection in solar flares

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Magnetic reconnection is a primary driver of magnetic energy release and particle acceleration processes in space and astrophysical plasmas. Solar flares are a great example where observations have suggested that a large fraction of magnetic energy is converted into nonthermal particles and radiation. One of the major unsolved problems in reconnection studies is nonthermal particle acceleration. In the past decade or two, 2D kinetic simulations have been widely used and have identified several acceleration mechanisms in reconnection. Recent 3D simulations have shown that the reconnection layer naturally generates magnetic turbulence. Here we report our recent progresses in building a macroscopic model that includes these physics for explaining particle acceleration during solar flares. We show that, for sufficient large systems, high-energy particle acceleration processes can be well described as flow compression and shear. By means of 3D kinetic simulations, we found that the self-generated turbulence is essential for the formation of power-law electron energy spectrum in non-relativistic reconnection. Based on these results, we then proceed to solve an energetic particle transport equation in a compressible reconnection layer provided by high-Lundquist-number MHD simulations. Due to the compression effect, particles are accelerated to high energies and develop power-law energy distributions. The power-law index and maximum energy are both comparable to solar flare observations. This study clarifies the nature of particle acceleration in large-scale reconnection sites and initializes a framework for studying large-scale particle acceleration during solar flares.