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Modeling Large-scale Electron Acceleration Associated with Magnetic Reconnection

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During solar flares, magnetic reconnection unleashes magnetic energy and drives strong electron acceleration and emission within minutes or shorter. Recent multi-wavelength observations (e.g., by EOVSA, RHESSI, and STIX) show that non-thermal radio and hard X-ray emissions could fill up a significant portion of the solar flare region. The electrons responsible for these emissions are thought to contain a substantial fraction of the released magnetic energy and often develop power-law energy tails with various spectral indices. In this study, we model the large-scale acceleration by solving the energetic particle transport equations using background MHD simulations with realistic boundary conditions to provide accurate magnetic field configuration and flow dynamics. Due to flow compression and shear effects, electrons can be accelerated to hundreds of keV and develop nonthermal power-law distributions, both of which are consistent with the observations. We quantify the relative importance of reconnection exhaust, magnetic islands, and flare looptop regions in accelerating nonthermal electrons and discuss the potential roles of second-order acceleration. The model-generated spatially and temporally dependent electron distributions can be used for producing synthetic radio or hard X-ray emission maps, which can be directly compared with radio and hard X-ray observations. These results have important implications for understanding large-scale electron acceleration during impulsive flares.

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