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Nonthermal Particle Acceleration and Radiation in Relativistic Magnetic Reconnection[1]

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Many spectacular and violent phenomena in the high-energy universe exhibit nonthermal radiation spectra, from which we infer power-law energy distributions of the radiating particles. Relativistic magnetic reconnection, recognized as a leading mechanism of nonthermal particle acceleration, can efficiently transfer magnetic energy to energetic particles. We present a comprehensive particle-in-cell study of particle acceleration in 2D relativistic reconnection in both electron-ion and pair plasmas without guide field. We map out the power-law index α and the high-energy cutoff of the electron energy spectrum as functions of three key parameters: the system size (and initial layer length) L, the ambient plasma magnetization σ, and the ion/electron mass ratio (from 1 to 1836). We identify the transition between small- and large-system regimes: for small L, the system size affects the slope and extent of the high-energy spectrum, while for large enough L, α and the cutoff energy are independent of L. We compare high energy particle spectra and radiative (synchrotron and inverse Compton) signatures of the electrons, for pair and electron-ion reconnection. The latter cases maintain highly relativistic electrons, but include a range of different magnetizations yielding sub- to highly-relativistic ions. Finally, we show how nonthermal acceleration and radiative signatures alter when the radiation back-reaction becomes important. These results have important implications for assessing the promise and the limitations of relativistic reconnection as an astrophysically-important particle acceleration mechanism.

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