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Particle Acceleration in 'Reconnecting' Turbulence

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Turbulence and magnetic reconnection are ubiquitous in astrophysical environments, and they are often invoked to explain the origin of non-thermal particles inferred to occur in a variety of astrophysical sources. Yet, the mechanisms responsible for accelerating particles to ultra-relativistic energies are still poorly understood. Recent fully-kinetic particle-in-cell simulations suggest that turbulence and magnetic reconnection operate in synergy, with reconnection being responsible for particle injection from the thermal pool and stochastic scattering off turbulent fluctuations leading to extended non-thermal power-law tails. The acceleration mechanisms, as well as the resulting particle distributions, depend on particle species. We find that the ion energy spectrum is harder than the electron one, and both distributions get harder for higher plasma magnetization. The energization of electrons is accompanied by a significant energy-dependent pitch-angle anisotropy, with most electrons moving parallel to the local magnetic field, while ions stay roughly isotropic. Parallel electric fields associated with magnetic reconnection are responsible for the initial energy gain of electrons, whereas perpendicular electric fields control the overall energization of ions. These findings have important implications for the origin of non-thermal particles in black hole accretion flows and jets.

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