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Stochastic particle acceleration by multifractal MHD turbulence in strong magnetic fields

Enrico Fermi first proposed the stochastic acceleration of protons due to interactions with parsec-scale interstellar magnetic fields as a method of cosmic ray acceleration around the time of the 1950s. Since then, the theoretical framework of stochastic acceleration in magnetohydrodynamic (MHD) turbulence has undergone significant refinement with recent numerical simulations incorporating more realistic multifractal MHD turbulence yielding previously unknown effects, such as intermittent particle energization characterized by large jumps in particle momenta. In this work, we numerically simulate the intermittent acceleration of a population of relativistic electrons as a continuous-time random walk, i.e., the time between energization events is described by a continuous random variable, based on the methodology developed in previous studies. We developed a Monte-Carlo code to simulate the effects of intermittent energization on the electron spectrum. This methodology was extended by incorporating intermittent synchrotron cooling into the existing theory for which an analytical expression for the change in electron momentum was found and incorporated into the Monte-Carlo approach. Our findings suggest particle spectra characterized by distinct low- and high-energy tails, differing significantly from those predicted by the standard Fermi theory.

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