Cosmic rays in intermittent random magnetic fields

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Abstract

We use test particle simulations of cosmic ray (protons) propagation in a random magnetic field at scales comparable to and less than the turbulence correlation scale (100 pc in spiral galaxies). Interstellar magnetic fields are highly intermittent due to both fluctuation dynamo and compression at shock fronts, and consist of magnetic filaments and ribbons. Magnetic intermittency significantly enhances cosmic-ray diffusion over a wide range of particle energies as compared to a Gaussian magnetic field with identical Fourier spectrum. We demonstrate that the particle motion can be described as a correlated random walk rather than the Brownian motion. We find that there is no spatial correlation between the cosmic ray number density and the energy density of the random magnetic field. Their spatial distributions are even statistically independent to a good accuracy. Nevertheless, the cosmic ray distribution is highly structured and clearly reflects some properties of the magnetic field. We demonstrate that cosmic rays are trapped between random magnetic mirrors whose location depends more on the structure of the field lines than on the field strength.

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