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Cosmic Ray Small-Scale Anisotropies in Slab Turbulence

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In the standard picture of cosmic ray transport the propagation of charged cosmic rays through turbulent magnetic fields is described as a random walk with cosmic rays scattering on magnetic field turbulence. This is in good agreement with the highly isotropic arrival directions as this diffusion process effectively isotropizes the cosmic ray distribution. However, high-statistics observatories like IceCube and HAWC have observed significant deviations from isotropy down to very small angular scales. This is in strong tension with this standard picture of cosmic ray propagation. By relaxing one of the assumptions of quasi-linear theory and explicitly considering the correlations between the fluxes of cosmic rays from different directions, we show that power on small angular scales is a generic feature of particle propagation through turbulent magnetic fields. We present a first analytical calculation of the angular power spectrum assuming a physically motivated model of the magnetic field turbulence and find good agreement with numerical simulations. We argue that in the future, the measurement of small-scale anisotropies will provide a new window to testing magnetic turbulence in the interstellar medium.

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Cosmic rays

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