Energetic Particle Perpendicular Diffusion: Simulations and Theory
in Noisy Reduced Magnetohydrodynamic Turbulence
การฟุ้งของอนุภาคพลังงานสูงในแนวตั้งฉาก : การจำลองและทฤษฎี
ในความปั่นป่วนแบบอุทกพลศาสตร์แม่เหล็กลดทอนแบบมีสัญญาณรบกวน

(A. P. Snodin, T. Jitsuk, **D. Ruffolo*,** and W. H. Matthaeus, Astrophys. J., 932, 127)

Cosmic rays are energetic particles from space. Most are charged sub-atomic particles, specifically ions and electrons. Their transport in space is dominated by turbulent magnetic fluctuations, leading to a random walk and diffusion of the particles. The rate of diffusion, as specified by the mean free path $\boldsymbol{\lambda}$, is found to be very different in directions parallel or perpendicular to the large-scale magnetic field.

The present work addresses simulations and theories of perpendicular diffusion in a particular type of magnetic turbulence: noisy reduced magnetohydrodynamic turbulence. This is scientifically interesting because there is a lack of resonant scattering for a wide range of particle energy and Larmor radius R_L, i.e., the maximum radius of gyration for a particle of a given energy in a specified large-scale magnetic field B_0. Therefore, the explanation of particle diffusion in this type of turbulence is particularly challenging to theories of perpendicular diffusion. We have compared calculations of $\boldsymbol{\lambda}_\perp$ from RBD/BC theory (Ruffolo et al. 2012) and UNLT theory (Shalchi 2010) with simulation results for various values of b/B_0, the ratio of turbulence amplitude to large-scale magnetic field amplitude, $l_\parallel/l_\perp$, the ratio of parallel to perpendicular length scales of the turbulence, and $R_L/l_\perp$. Both theories give results in qualitative agreement, and RBD/BC is usually in better agreement with the simulation results.

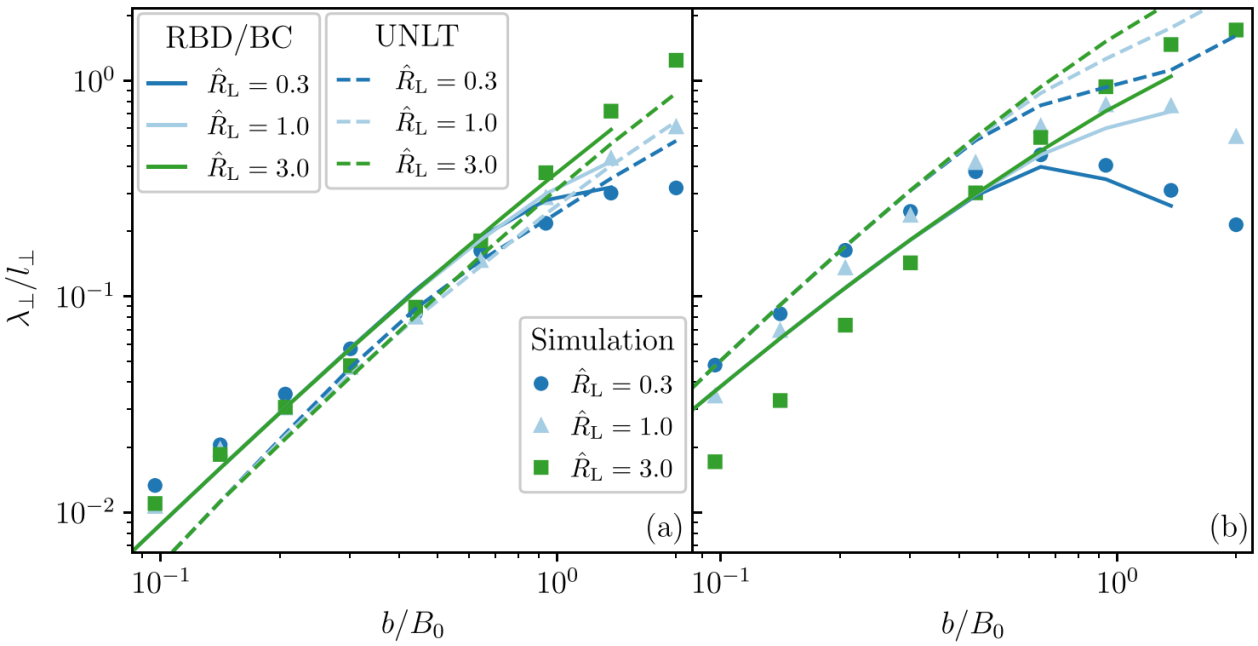

Figure: Perpendicular test particle diffusion coefficient in NRMHD turbulence (symbols) for (a) $l_\parallel/l_\perp = 1$ and (b) $l_\parallel/l_\perp = 10$ as a function of b/B_0 for varying $R_L/l_\perp$, compared with NLGC RBD/BC theory (solid lines) and UNLT theory (dashed lines). The theory results basically remain close to the simulation results, though the theories do not exhibit an R_L dependence at $b/B_0 = 1$ in panel (b).