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WPIT101 (Introduction to Wave-particle Interactions in Turbulence): Micro-physics of Charged Particle Transport in Turbulent Magnetic Fields

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Terms such as pitch-angle scattering and parallel or momentum diffusion are frequently used in plasma physics and transport theory when the propagation of charged particles in turbulent magnetic fields are considered. Regardless of the wide use of these terms, their exact implications or physical descriptions are often not well understood or misunderstood. Would you be able to draw a picture of perpendicular diffusion if asked to? This work attempt to build a conceptual understanding of magnetic turbulence's influence on the movement of charged particles. This is done by constructing toy slab, 2D, and composite slab-2D turbulence models and solving the Newton-Lorentz equation numerically for particles propagating in these turbulence models. It is seen that the classical idea of particle scattering or hard-sphere collisions, where particles physically collide or particles are deflected by some interaction potential between particles, cannot and should not be naively applied to charged particles interacting with turbulence. This is due to the physical interaction between charged particles and magnetic scattering centres being of an unique nature. It is shown that the motion of the particle itself is smooth and continuous, although it follows a highly perturbed spiral path. It is only when the particle's guiding centre is considered, that the classical scattering idea can be applied as its motion is more irregular and display abrupt changes. The insights gained in this work do not only allow a better conceptual understanding of the various terms, but also to visualize the various processes described by these terms.

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