

Redistribution of fast particles by background turbulence

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Although it is widely believed that fast particles – like alpha particles or beam ions – do not interact significantly with the background turbulence, our present understanding of this issue is still relatively poor. And as will be shown in our presentation, this basic intuition is not true in general. In order to understand the basic mechanisms determining the turbulent diffusion of fast particles, we perform direct numerical simulations of test particles in prescribed electrostatic potentials. First, these potentials are random and two-dimensional; then, we consider three-dimensional potentials produced by the gyrokinetic turbulence code GENE.

Using an idealized isotropic potential with Gaussian statistics, numerous test particle simulations are done varying both the gyroradius and the Kubo number of the potential. It is found that for Kubo numbers larger than about unity, the particle diffusivity is almost independent of the gyroradius as long as the latter does not exceed the correlation length of the potential. For smaller Kubo numbers, on the other hand, the diffusivity is reduced monotonically. The underlying physical mechanisms are identified and an analytic approach is developed which favorably agrees with the simulation results. These investigations are then extended by introducing anisotropic structures like streamers and zonal flows as well as drift effects into the random potential. Analytic models are used to explain these various effects.

Having developed a general picture of the behavior in simplified artificial potentials, test particle simulations in realistic turbulent fields are presented. They are compared to the previous results which enable us to understand the interaction between the wide number of effects present at the same time, including drift orbit averaging. Finally, implications for present-day experiments and ITER are discussed.