A-Langevin approach for the diffusion of test particles in stochastic magnetic fields within the Corrsin approximation

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Motion of charged particles in a collisional plasma with stochastic magnetic field lines is considered. Within a statistical description, test particle motion can be described by the so called A-Langevin model. Compared to the previously used V-Langevin model [1, 2, 3], here finite Larmor radius effects are taken into account. Besides ion test particle transport in tokamaks, finite Larmor radius effects are, e.g., important for transport of cosmic rays in chaotic magnetic fields [4]. Here, the A-Langevin equations are solved under the assumptions that the Eulerian correlation function for the magnetic field fluctuations has a Gaussian form and that the Corrsin approximation [5] can be applied to formulate an appropriate Lagrangian correlation function. The velocity correlation function, being averaged with respect to the stochastic variables including collisions, follows straightforwardly, resulting in an implicit differential equation for the mean-square-displacement. From the latter, different transport regimes, including the well-known Rechester-Rosenbluth diffusion coefficient, are derived. We recover the V-Langevin results in the strong guiding field limit. The weak guiding field limit as well as finite Larmor radius effects are discussed.

It is well-known that the Corrsin approximation is valid only for small Kubo numbers. The recently developed method of decorrelation trajectories [6, 7] applies also for large Kubo numbers. Using some ideas from the method of decorrelation trajectories, the paper is concluded by new results in the percolation limit.

References

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