Stochastic modeling of plasma edge turbulence

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Different models for guiding centre drifts motion in a stochastic magnetic or electrostatic fields are described. They either introduce new physics in the Langevin formalism or are adapted to the description of a particular physical phenomena.

One of the models considers temperature fluctuations in a system where particles are moving in a stochastic magnetic field. Here the random time between collisions is stretched by a gaussian interruption process. All the variables up to the spatial displacement are thus non gaussian but can nonetheless be described exactly. We show that, as in the case of a gaussian collision process, the asymptotic state despite of being non gaussian still leads to a subdiffusive particle mean square displacement.

A more radical treatment is therefore necessary to get superdiffusive behavior. One of the possibility is to describe the magnetic fluctuations as being determined by a Levy distribution. In that case, also, one is able to get analytical results. Relations to a fractional kinetic equation is established.

Finally, the extreme heavy tail and the power-law decay of the electrostatic turbulent flux correlation observed in hot magnetically confined plasmas are modeled by a system of coupled Langevin equations describing a continuous time linear randomly amplified stochastic process where the amplification factor is driven by a superposition of colored noises which, in a suitable limit, generate a fractional Brownian motion. An exact analytical formula for the power-law tail exponent is derived. In this case, the extremely small value of the heavy tail exponent and the power-law distribution of laminar times also found experimentally are obtained as a consequence of the (asymptotic) self-similarity property of the noise spectrum. As a by-product, a new representation of the persistent fractional Brownian motion is obtained [1].

References

[1] G. Steinbrecher and B. Weyssow, PRL, **92** (2004) 125003.