Nondiffusive transport in plasma turbulence

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Experimental evidence indicates that transport in magnetically confined fusion plasmas deviates from the standard diffusion paradigm. In particular, transport in fusion plasmas lacks of characteristic scales in space and time. Several theoretical approaches have been explored in the last years to explain these experimental findings. Among them, continuous-time random walk (CTRW) models with Lévy probability distribution functions (pdf) stand out since transport lacks any characteristic scale in these models [1]. In the fluid limit, these models lead to a description of transport in terms of fractional differential equations [2].

Here, we try to confirm the existence of this kind of distributions in numerical simulations of plasma turbulence. We have followed the evolution of fluctuations for three different fluid models: 1. pressure-gradient-driven turbulence in toroidal geometry (ballooning modes) [3]; 2. dissipative trapped electron mode in cylindrical geometry [4]; 3. tearing modes in cylindrical geometry. The first two correspond to electrostatic turbulence in tokamaks, and the third one to magnetic turbulence in a reversed field pinch.

To characterize the transport properties induced by the turbulence, we investigate the time evolution of pseudo-particle tracers. From the information on tracer orbits, we calculate the pdf of flights, and determine power-law tail exponents. From the information on the Lagrangian correlations along the particle tracer orbits, we determine the Hurst exponent. The results for the electrostatic modes show that the transport is superdiffusive and non-Markovian [3]. We are now characterizing the transport for the magnetic simulation.

References

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