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Coherence and memory in turbulence

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The evolution of turbulence in magnetically confined plasmas is a complex problem that is not completely understood in spite of a huge amount of work. Low-frequency drift type turbulence, which has a significant influence on fusion plasma confinement, is analyzed here with the aim of understanding the memory effects on turbulence evolution.
We present a theoretical study based on a statistical Lagrangian approach. Essentially, the growth rates of test modes are determined as functions of the statistics of ion trajectories. The original contribution in this method consists of the deep statistical analysis of the ions, which relies on conditioned averages (on subensembles of trajectories) and reveals the coherence of their motion. Coherent (average) displacements and velocities are found in each subensemble, but they are hidden in the sense that their contributions compensate on the whole space of trajectories. However, the dispersion of the trajectories and the transport are essentially determined by these coherent elements. We have shown that a slow time variation of the potential has not the expected effect of attenuation of the coherent components. A surprising enhancement of coherence appears, associated to long-time memory of the Lagrangian potential. The memory time is much longer than the correlation time of the turbulence. As a consequence, the growth rates and the frequencies of the test modes are intrinsically time-dependent. They determine oscillatory behavior of the amplitude of turbulence with the characteristic memory time. Such evolution is in agreement with the results of numerical simulations and experimental measurement.
In conclusion, the main finding of this work is the explanation of the small frequency oscillations of drift turbulence amplitude as the effect of the memory associated to the coherent components of the ion motion.

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