Describing inhomogeneous drift-wave turbulence from a phase-space perspective

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Abstract

The self-organization of incoherent drift-wave (DW) turbulence into coherent zonal-flow (ZF) structures is a topic of wide interest in the atmospheric and fusion-energy sciences. In this talk, I show that the interaction between DW turbulence and ZFs can be modeled as an effective quantum plasma. This alternative formulation treats DW quanta (“driftons”) as particles in phase space interacting with one another via the ZF velocity, which serves as a collective field. The derivation of the model is based on the Weyl calculus and on the quasilinear approximation. As a result, the drifton dynamics is described by an equation of the Wigner–Moyal type, which is commonly known in the phase-space formulation of quantum mechanics. Additional insights gained from this model are discussed. For example, in the geometrical-optics limit, this formulation leads to a wave kinetic equation for driftons that ensures exact conservation of the total enstrophy and energy of the system. Numerical simulations are presented in order to compare the derived model with previous works. Towards the end of the talk, I present recent advances in constructing a DW turbulence model that goes beyond the quasilinear approximation. In the geometrical-optics limit, this model leads to a wave kinetic equation for driftons that includes an effective wave–wave collision term, which can lead to an inverse-energy cascade and is not captured by quasilinear DW–ZF models.

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