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Two-dimensional turbulence in three-dimensional flows

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First experiments on turbulence in thin fluid layers designed to model two-dimensional (2D) turbulence confirmed basic expectations of Kraichnan's theory [1], namely the existence of the inverse energy cascade and the generation of the Kolmogorov k-5/3 spectrum (e.g [2-4]). Later it has been realized that these are not restricted to thin layers, but are rather universal properties of flows in thick layers [5,6]. The presence of coherent structures, either self-generated via spectral condensation in bounded flows, or externally imposed, enforces two-dimensionality in the flow securing the inverse energy cascade and the energy transfer towards large scales [7]. Recently a similar scenario has been reported from the aircraft measurements in the hurricane boundary layer [8]. It has been shown that at heights above 150 m the sign of the third-order structure function is positive, indicating the inverse energy cascade and the possibility that a hurricane may actually gain energy from small scales. Even more recently it has been discovered that motion of fluid parcels on the surface of the Faraday ripples represents an excellent model of 2D turbulence [9]. Such turbulence exhibits the inverse energy cascade, and if bounded, can generate large scale coherent structures due to spectral condensation on the box size [10]. In this talk we will compare and analyze manifestations of 2D turbulence in 3D flows and will discuss potential applications and new ideas relevant to the atmospheric boundary layer physics.

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