Turbulence-generated vortices in fluid layers

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Under the pumping at intermediate scales and small-scale dissipation, an inverse cascade in a finite box tends to produce a coherent box-size flow called condensate. If that condensate is stable, it grows, as is the case for incompressible 2d turbulence and optical or Langmuir turbulence with repulsive (defocusing) nonlinearity. If the condensate is unstable, as is the case for optical and Langmuir turbulence with attractive (focusing) nonlinearity, it produces finite-time singularities (self-focusing or wave collapse) which stabilize turbulence at large scales. Here we discover a third possibility: inverse cascade in a compressible 2d turbulence (also turbulence in a thin fluid layer) produces box-size long-living vortices, which fluctuate and oscillate strongly and are accompanied by large-scale shock waves that dissipate the energy. Turbulence provides for a net energy flux into vortex but a zero net momentum flux. We analyze the spectra of kinetic energy and density in both intervals of direct and inverse cascade and show different physics that determines those cascades in compressible 2d turbulence.We present both basic analytic theory and extensive numerics.