Forward energy cascade in 2D turbulence with curvature

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Three-dimensionnal turbulence is usually characterized by a cascade of energy from large to small scales associated with a fragmentation of structures. However in the case of 2D turbulence there is a self-organization of large structures caused by an inverse cascade of energy from forcing scales to larger scales. An intermediate state between pure 2D turbulence and 3D turbulence is 2D3C turbulence (three velocity component turbulence but evolving in a plane). 2D3C flows can therefore exhibit 2D and 3D characteristics depending on the parameters of the flow. For instance a direct cascade is observed in the presence of curvature[1].

We explore the transition between 2D2C and 2D3C turbulence in an axisymmetric flow. The domain is a periodic square representing a subsection of the poloidal cross-section of a torus. Numerical simulations are performed with the pseudo-spectral code GHOST[2]. A linear forcing is applied independently in the poloidal direction (in the plane of the cross-section) and the toroidal direction (perpendicular to the cross-section). A cubic damping is applied in order to avoid computations to blow-up. The ratio of the intensity of these forcings is the key parameter which determines the characteristics of the flow. The variation of the ratio triggers the transition from 2D2C to 2D3C turbulence, characterised by the onset of a direct energy cascade and the break-down of large structures.

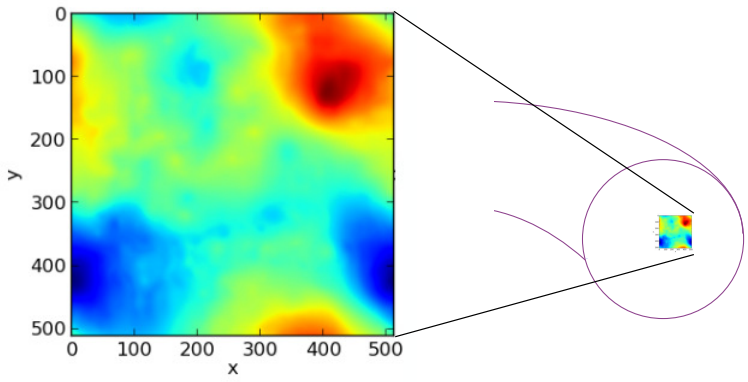

Figure 1: Stream function in axisymmetric turbulence before the onset of a direct energy cascade.

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[1]Qin et al., *Physical Review Fluids* **5(6)**, 064602 (2020)
[2]Mininni et al., *Parallel Comput.* **37** (2011).