Sudden relaminarisation and lifetimes in forced isotropic turbulence

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Abstract

This talk is concerned with an unexpected connection between isotropic turbulence and wall-bounded parallel shear flows. In direct numerical simulations of isotropic turbulence forced at large scales at moderate Reynolds numbers sudden transitions from chaotic dynamics to a spatially simple flow are observed, analogous to relaminarisation events in wall-bounded parallel shear flows. The large-scale ordered flow is identified as a superposition of specific ABC-flows, and results from simulations subjecting it to random perturbations of variable amplitude demonstrate that it is a linearly stable simple exact solution of the Navier-Stokes equations that can be destabilised by a finite-amplitude perturbation, like the Hagen-Poiseuille profile in pipe flow. Furthermore, the survival probabilities of turbulence are exponential and the typical lifetimes increase super-exponentially with the Reynolds number, similar to results on relaminarisation of localised turbulence in pipe and plane Couette flow. As such, relaminarisation events in isotropic turbulence and in wall-bounded shear flows have the same statistical signature. These results suggest that both isotropic turbulence and wall-bounded shear flows may qualitatively share the same phase-space dynamics.