Understanding finite life-times of Newtonian turbulence

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ABSTRACT

Recently, our understanding of the transition to Newtonian turbulence has significantly changed due to the discovery of exact solutions of the Navier-Stokes equations and the introduction of the self-sustaining process by which Newtonian turbulence in parallel shear flows is sustained [F. Waleffe, Phys. Fluids, v.9, 883 (1997)]. In this mechanism, a small number of coherent structures (streamwise vortices, streaks and 3D vortices) are able to sustain themselves via a series of non-linear interactions and instabilities. This theory, dubbed the self-sustaining process, has been very successful in describing the main features of weakly turbulent states close to the transition threshold. One of the main predictions of the theory is that close to the transition, turbulence is metastable. The question remains whether this is true for all Reynolds numbers or there is a transition to stable turbulence at a sufficiently large Reynold number. This question is a subject of active debate in the field.

In this talk I will present an attempt to answer this question for a simple model equation constructed to mimic the transition to turbulence. First, I will demonstrate that it has all the features of true turbulent dynamics, and then analyse the finite life-times in this system. It appears that the life-times can be understood in terms of survival probabilities in a simple non-equilibrium statistical mechanics model.