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# Out of equilibrium statistical mechanics and stochastic dynamics of two dimensional flows

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One of the most important problem in turbulence is the ***prediction of large-scale structures of very high Reynolds' flows***. For the 2-D Euler equation and related geophysical equations, a statistical mechanics explanation of their self-organization has been proposed by Robert, Sommeria and Miller (RSM). However, this inertial theory does not predict the long-term effects of the forcing, which is a relevant issue for any application. It is a practical and fundamental problem to understand how the invariants are selected by the presence of some weak dissipation and forcing, and if the resulting large-scale flows are close to some inertial equilibrium ?

We consider two-dimensional flows with weak stochastic forcing and dissipation in the inertial limit. The existence of an invariant measure has been mathematically proved recently, together with mixing and ergodic properties. This problem has however never been considered from a physical point of view. We thus address the following issues: ***when is the measure concentrated on an inertial equilibrium, how are the large scales selected by the forcing, what is the level of the fluctuations ?***

This study is based on theoretical predictions, intensive numerical computations, and for simple basic situations, on rigorous mathematical results. We infer from numerical studies that large-scale stationary flows are actually close to some inertial equilibrium. ***In a situation of phase transition, by tuning the forcing, we can obtain flows with different topologies, as predicted by the RSM theory. Discrepancies between our numerical experiments and the RSM theory are also discussed.***

We also address the ***stochastic stability of RSM equilibrium, for the linearized Navier Stokes equation with weak random forcing***, both from a theoretical and numerical point of view.