Lagrangian chaos for models in fluid mechanics

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Abstract

In models of fluid mechanics, the Lagrangian flow ϕ^t describes the motion of a passive particle advected by the fluid. It is anticipated that in many regimes (e.g., when the fluid is subjected to some forcing/stirring) that the Lagrangian flow ϕ^t should be chaotic in the sense of sensitivity with respect to initial conditions. I will present a recent joint work with Jacob Bedrossian (U Maryland) and Sam Punshon-Smith (Brown U) in which we rigorously verify this chaotic property (i.e., the presence of a positive Lypaunov exponent) for various incompressible and stochastically forced fluid models on the periodic box, including stochastic 2D Navier–Stokes and stochastic hyperviscous 3D Navier–Stokes. A consequence of our work is a rigorous verification of Yaglom's law, a scaling law for passive scalar advection analogous to the famous Kolmogorov 4/5 law for turbulence in the Navier–Stokes equations.