LAGRANGIAN TURBULENCE MODELS OF THE VELOCITY GRADIENT TENSOR AND APPLICATIONS IN LES

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Intermittency of small-scale motions is an ubiquitous facet of turbulent flows, and predicting this phenomenon based on reduced models derived from first principles remains an important open problem. We present a multiple-time scale stochastic model for the Lagrangian evolution of the full velocity gradient tensor in fluid turbulence, at arbitrarily high Reynolds numbers. Unlike previous phenomenological models of intermittency, in the proposed new model the dynamics driving the growth of intermittency due to gradient self-stretching and rotation are derived directly from the Navier-Stokes equations. Numerical solutions of the resulting set of stochastic differential equations show that the model predicts anomalous scaling for moments of the velocity gradient components and negative derivative skewness. It also predicts signature topological features of the velocity gradient tensor such as vorticity alignment trends with the eigendirections of the strain-rate. We also explore how to implement similar models into predictive computational tools such as Large Eddy Simulations. This research is performed with Perry Johnson and had support from the National Science Foundation.