Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Lagrangian velocity-gradient evolution: Closure modeling conditioned on local streamline geometry. RISHITA DAS, SHARATH GIRIMAJI, Texas AM University — We develop a stochastic diffusion model for the evolution of velocity gradient tensor ($A_{ij} \equiv \partial u_i/\partial x_j$) following a fluid particle in isotropic incompressible turbulent flow. Two primary challenges toward accurate modeling of turbulence velocity-gradient dynamics are (i) intermittent nature of A_{ij} and (ii) non-locality of pressure and viscous terms in its evolution equation. To overcome these difficulties, we factorize A_{ij} into its intermittent magnitude ($A \equiv \sqrt{(A_{kl}A_{kl})}$, streamline scale) and normalized velocity gradient tensor ($b_{ij} \equiv A_{ij}/A$) which fully determines the local streamline shape. It is first shown that the evolution of magnitude A does not require any additional closures, once b_{ij} equation is suitably modeled. Then, the evolution of mathematically bounded tensor b_{ij} is modeled using a stochastic differential equation, and the non-local pressure and viscous terms are modeled with closures conditioned on local streamline shapes. The key advantages of this approach are:(i) relative ease of modeling the bounded tensor b_{ij} and (ii) amenability of conditioning nonlocal processes upon local streamline shape. The model accurately captures one-time statistics of isotropic turbulence, including high-order moments of A_{ij}, streamline-shape distribution and vorticity-strain rate alignment.

Rishita Das
Texas A
M University

Date submitted: 02 Aug 2020 Electronic form version 1.4