Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

A Mesoscopic Model for the Description of Small-scale Inhomogeneity in Turbulent Flows with Thermal Nonequilibrium VENKAT RAMAN, ROMAIN FIEVET, University of Michigan, PETER CLARKE, PHILIP VARGHESE, The University of Texas at Austin — Turbulent mixing of nonequilibrium flows exhibit certain anamolous properties as compared to equilibrium flows. In high-speed flows where the vibrational or rotational relaxation occurs over time and length-scales comparable to flow-through times, there a unique non-homogeneity introduced at the small-scales: The molecules are spatially homogeneous but their internal motions still exhibit inhomogeneity. This differential relaxation rate poses hurdles in the direct numerical simulation of turbulent nonequilibrium flows. In this work, a mesoscopic description of this homogeneity is introduced. Using a probabilistic model, the inhomogeneous vibrational modes are tracked as a function of space and time. Further, direct numerical solutions of the extended Boltzmann equation are used to develop mesoscopic closure models for this stochastic description. Simulations of representative scramjet isolators are used to illustrate the applicability and relevance of this mathematical description.

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Date submitted: 01 Aug 2015 Electronic form version 1.4