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Recent developments in theory and simulation of turbulent mixing

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We report on recent developments of the authors and coworkers on theory and simulation of turbulent mixing. Our main theoretical results are new and improved closures for averaged equations. We have simulations consistent with experiment for RT mixing and a quantitative explanation of the failure of many simulation codes to do this. New front tracking algorithms will enable improved simulations of the complex microphyics of mixing.

1. Theory

We report on two new developments for the closure of averaged equations. We continue our study of the complete first order closure of the multiphase equations, in that each phase has complete and independent thermodynamic parameters. We extend the incompressible closure to an arbitrary number n of fluids. We specify the interfacial velocities as a function of the phase mean velocities in a new closure relation. For n = 2 compressible fluids, a new closure satisfies energy conservation and for smooth flows, conservation of phase entropy. An analysis of the entropy of averaging supports this closure.

2. Simulations

Analysis of interfacial mass diffusion in most simulations can account quantitatively for observed simulation-experimental discrepancies. A similar analysis accounts for compressibility induced density stratification effects on RT mixing rates, even in the absence of interfacial mass diffusion. Experimentally validated RT mixing methods (using front tracking) are used to predict turbulent combustion rates in the RT burning of a type Ia supernova.

3. Numerical methods

A totally conservative front tracking algorithm has been developed, which yields higher order convergence rates even with solution discontinuities. This algorithm will allow feasible simulations of greatly improved quality of the microphysics of mixing.

Front Tracking has been merged with the AMR capability of the LLNL OVERTURE code. It has also obtained a rad-hydro capability through merger with the 1D rad-hydro code Hydes.