Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, November 8, 2016
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Numerical Simulations of Waves, Shocks, and Blasts Interacting with Interfaces in Highly Compressible Multiphase Flows

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Developing a highly accurate numerical framework to study multiphase mixing in high speed flows containing shear layers, shocks, and strong accelerations is critical to many scientific and engineering endeavors. These flows occur across a wide range of scales: from tiny bubbles in human tissue to massive stars collapsing. The lack of understanding of these flows has impeded the success of many engineering applications, our comprehension of astrophysical and planetary formation processes, and the development of biomedical technologies. We present advances in the three fields of numerical methods, high performance computing, and multiphase flow modeling: (i) novel Discontinuous Galerkin numerical methods to capture accurately the multiphase nature of the problem; (ii) modern high performance computing paradigms using the Message Passing Interface and Graphics Processing Units to resolve the disparate time and length scales of the physical processes; (iii) new insights and models of the dynamics of multiphase flows, including mixing through hydrodynamic instabilities.

Implications of Background Stratification on the Compressible Rayleigh Taylor Instability

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Rayleigh Taylor instabilities (RTIs) arise when a denser fluid is suspended above a less dense fluid in the presence of a body force with the direction of the acceleration opposite to that of the density gradient. After applying a perturbation to the interface between these two fluids, the heavier begins falling in a spike as the light begins rising in a bubble. The vorticity generated by this motion and the resulting Kelvin-Helmholtz instability causes these bubbles and spikes to grow in an increasingly nonlinear fashion and if the Reynold's number is high enough, this will lead to chaotic growth. Previously, these effects have been studied in the incompressible regime, and though many engineering scenarios involving RTIs are highly compressible, little is known about the additional effects that arise. To investigate, wavelet based direct numerical simulations have been performed with a variety of differing background stratifications. It has been found that the effects of the stratified background density lead to new regimes in the growth of low Atwood number RTIs, namely the exaggeration of bubble and spike asymmetries in the weakly stratified background state and complete suppression of the growth in the strongly stratified scenario. In order to better understand these results, the individual terms of the vorticity transport equation are analyzed and compared to the analogous results for the simplified cases of counter rotating vortex pairs in stratified media.