Multi-phase Flows — overview

The multi-phase flow activities for this Summer Program consisted of eight projects focused on diverse aspects in terms of physics, modeling, and computational challenges. These projects involved three major themes: phase interfaces in two-phase flows, particle-laden turbulence in multi-physics environments, and multi-scale statistics in turbulent flows.

The projects involving two-phase flows were themed around the challenge of accurate and conservative numerical treatment of interfaces and mixing in compressible flows, including conditions at high pressures. In one project, Herrmann developed a numerical scheme that extended the geometric VoF scheme to the compressible multi-phase flow regimes, which consists of a novel treatment that allows simultaneous capturing of sharp interfaces as well as shocks within a unified Eulerian simulation framework. Adami *et al.* used a compressible two-phase flow methodology based on the level-set approach to investigate multi-physics effects in biomedicine applications. They studied shock-bubble interactions near a deformable solid as a model surrogate for understanding the cell membrane poration during shock-wave lithotripsy. The last project in this subgroup was focused on numerical modeling for LES of high-pressure two-phase flows in the transcritical regime involving liquid-fuel injection and mixing. In this project, Hickel and Matheis investigated different discrete representations of a pressure-based energy formulation for transcritical flows and systematically assessed their accuracy for LES conditions.

Two projects were focused on high-fidelity modeling of multiphysics effects in particle-laden turbulent flows in specific applications. Moureau's project (Dufresne *et al.*) considered particle-laden flows in the context of fluidized bed reactors and investigated the sensitivity in prediction of combustion regimes on computational models and numerical discretizations. Rahman *et al.* investigated the transport of electrically charged particles in turbulent boundary layers to shed light on the mechanisms leading to generation of lightning in sandstorms. To achieve this goal, they developed an Eulerian particle transport algorithm that included the effects of Coulomb forces on the particles.

Lastly, the group worked on three projects that were focused on development and utilization of effective statistical tools for interpretation of multi-phase turbulent flows. The project led by Schneider and Farge (Kadoch *et al.*) investigated the statistics of trajectories of inertial particles subject to a turbulent flow environment. By establishing an understanding of the effects of the particle Stokes number on these statistics, they developed a new framework for the assessment of LES models for particle-laden flows. In Apte's project, He *et al.* studied turbulence in confined geometries and the impact of confinement on fluid dispersion, including pore-scale dispersion by examining the Eulerian and Lagrangian correlations from DNS data of turbulent flows at different pore Reynolds numbers. The last project, which was led by Doostmohammadi (Urzay *et al.*), addressed turbulent-like flows of active matter. By analyzing DNS data using multi-scale statistical tools such as wavelets, they were able to quantify similarities and differences between active and classic turbulent flows beyond simple visual inspections.

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