Simulating Atomization

The atomization of liquids is a key process in many natural phenomena and technical applications. It is typically the first in a sequence of steps that ultimately results in energy conversion in the form of combustion. It can thus strongly impact combustion stability, efficiency, and pollutant production. Commonly, atomization is thought to occur in two consecutive steps: the initial primary atomization of the liquid into large and small scale structures, followed by the secondary atomization of these structures into ever smaller drops. While a number of established models exist for the latter process, the details of the former process are as of this day not fully understood. Detailed numerical simulations can help study the fundamental mechanisms of the initial breakup in regions, where experimental access and analysis is virtually impossible. However, simulating atomization accurately is a tremendous numerical challenge since time and length scales vary over several orders of magnitude, the phase interface is a material discontinuity, and surface tension forces are singular.

In this talk recently developed numerical techniques to simulate atomization will be discussed. To achieve a simulation tool that is predictive, special focus must be placed on both code and solution verification. A novel method of applying the Method of Manufactured Solutions to one-fluid formulations will be presented, demonstrating that even in the presence of discontinuous immiscible interfaces, finite volume methods for scalar equations are at least first-order accurate in the infinity norm. Several remaining challenges to achieve a truly predictive simulation tool for atomization will be discussed. Finally, simulation results for the atomization of a turbulent liquid jet injected into a gaseous crossflow, a turbulent liquid jet injected into pressurized still air, and a single drop subjected to a turbulent crossflow will be presented.

Biography

Marcus Herrmann received his Diploma and Ph.D. in Mechanical Engineering from the University of Technology (RWTH) Aachen, Germany. He was a visiting scientist at the University of Technology Eindhoven, The Netherlands and postdoctoral fellow and research associate at the Center for Turbulence Research (CTR) at Stanford University. He joined the faculty of Arizona State University in 2007. His main research areas are numerical methods for tracking interfaces, the simulation and modeling of turbulent multiphase flows during atomization processes, and turbulent premixed and partially premixed combustion.