Direct Numerical Simulations of Complex Multiphase Flows

Gretar Tryggvason, Ph.D.
Johns Hopkins University

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ABSTRACT

Direct numerical simulations (DNS), where every continuum length and time scale are fully resolved, allow us to follow the evolution of complex flows for sufficiently long time so that meaningful statistical quantities can be gathered. Results for relatively simple multifluid and multiphase systems with bubbles and drops in turbulent flows are now available, but new challenges are emerging. First of all, DNS of very large systems are yielding enormous amount of data that, in addition to providing physical insights, opens up new opportunities for the development of lower order models that describe the average or large-scale behavior. Recent results for bubbly flows and the application of machine learning tools to extract closure models from the data suggest one possible strategy. Secondly, success with relatively simple systems calls for simulations of more complex problems. Multiphase flows often produce features such as thin films, filaments, and drops that are much smaller than the dominant flow scales and are well-described by analytical or semi-analytical models. Recent efforts to combine semi-analytical models for thin films using classical thin film theory, and to compute mass transfer in high Schmidt number bubbly flows using boundary layer approximations, in combination with fully resolved numerical simulations of the rest of the flow, are described.

Bio: Gretar Tryggvason is the Charles A. Miller, Jr. Distinguished Professor at the Johns Hopkins University and the head of the Department of Mechanical Engineering. He received his PhD from Brown University in 1985 and was on the faculty of the University of Michigan in Ann Arbor until 2000, when he moved to Worcester Polytechnic Institute as the head of the Department of Mechanical Engineering. Between 2010 and 2017 he was the Viola D. Hank professor at the University of Notre Dame and the chair of the Department of Aerospace and Mechanical Engineering. Professor Tryggvason is well known for his contributions to computational fluid dynamics; particularly the development of methods for computations of multiphase flows and for pioneering direct numerical simulations of such flows. He served as the editor-in-chief of the Journal of Computational Physics 2002-2015, is a fellow of APS, ASME and AAAS, and the recipient of several awards, including the 2012 ASME Fluids Engineering Award.