Multi-phase Flows — overview

There is nothing more exhilarating for the scientist and the engineer than to find seemingly insurmountable technical problems on which one could spend decades in pursuit of solutions. One notable characteristic that differentiates everlasting problems in engineering physics from those that will be solved in our lifetime is the preponderance of multiple length and time scales, because multiple scales lead to multiple dimensionless parameters, and multiple dimensionless parameters lead to multiple regimes, and multiple regimes lead to many possible approximations, and many of these approximations in fluid mechanics must be navigated through singular perturbation parameters in nonlinear conservation equations, and these multiple singular limits lead to multiple spatio-temporal regions, and all this welter of complexities is hardly rationalizable in simple mathematical terms even for the most inquisitive mind. Today's impossible problems are, however, the problems of the future, and the problems one should be working on. And for all these reasons, and because the field of multi-phase flows is borne of many of these unforgiving problems, the participants in the group on Multi-phase Flows came to the Summer Program with a list of challenging questions, all of which remained unsolved after having done much hard work by the time the Summer Program ended – a clear sign that the problems were worthy of investigation.

The specific topics addressed by the Multi-phase Flow group were subdivided into two themes: i) dispersed particle-laden turbulent flows, and ii) two-phase turbulent flows. In this Summer Program, this group addressed problems that involved multi-phase flows subjected to electric effects, flow rotation, high-speed compressibility effects, phase change, and porosity. This is an expression of the particular emphasis made at the time of review of project proposals that the selected projects should encompass multi-physics aspects of relevance for emerging engineering applications.

In the area of dispersed particle-laden turbulent flows, the group focused on fundamental analyses of dispersion and deposition of inertial particles in complex flows. Di Renzo *et al.* investigated the utilization of electric fields for controlling the near-wall accumulation of particles in turbulent channel flows. Bragg & Dhariwal studied the dynamics of particles as a result of centrifugal forces in rotating turbulence. Vartdal & Osnes analyzed the turbulent fluctuations and forces created by shock waves moving through clouds of particles. Jain *et al.* addressed the problem of ingestion of sand grains in aircraft engines and their deposition on hot turbine blades downstream of the combustor.

In the area of two-phase turbulent flows, the group investigated the interactions of turbulence with liquid/gas interfaces and with porous media. Herrmann *et al.* formulated novel subgrid-scale models for predicting the corrugation of interfaces by turbulence. Lai & Fraga searched for fundamental explanations to the spectral-energy decay of turbulence observed in rising columns of bubbles. Brandt *et al.* studied the deformation of droplets and bubbles in homogeneous shear turbulence. To close the list of activities, Apte *et al.* derived a mesoscopic model to describe turbulent flows through porous media.

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