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WHAT CAN BE LEARNED FROM LES OF PARTICLE-LADEN TURBULENT FLOWS

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ABSTRACT

Numerical simulation continues to evolve as an important tool in the analysis and prediction of two-phase turbulent flows. Computations are playing an increasingly important role as both a means for study of the fundamental interactions governing a process or flow, as well as forming the backbone for engineering predictions of physical systems. At a practical level, computations for engineering applications continue to rely on solution of a statistically-averaged equation set. Many of the statistical correlations requiring closure in Reynolds-averaged models are often difficult or impossible to measure in experimental investigations of two-phase flows. Computational techniques that directly resolve turbulent eddies are an important component in evaluating closure models, while at the same time offering a useful approach for basic studies of fundamental interactions.

The focus of the lecture is on numerical prediction and study of turbulent two-phase flows using computational techniques such as Large Eddy Simulation (LES) that directly resolve the large, energy-containing scales of the turbulent motion. Within this broad class, the subset of two-phase flows in which a dispersed phase is comprised of small particles and is present at low volume fractions is of primary interest, using Lagrangian computational techniques for the prediction of trajectories of a large ensemble of discrete particles. The scope of such an approach considered is on systems in which the ensemble comprising the particulate phase is large enough that direct resolution of the flow in the vicinity of each particle is not feasible and, consequently, models on fluid-particle interfacial transfer and particle-particle interaction must be imposed.

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The advantages and limitations of such a technique are first considered and its accuracy is evaluated by comparison with discrete particle simulations coupled with fluid turbulence predictions obtained using DNS (understood in the present context as solution of the carrier-phase flow without the use of explicit subgrid turbulence models). An overview and examples of the application of LES to prediction and scientific study of dispersed, turbulent two-phase flows is then presented for several representative flow configurations: statistically stationary and decaying particle-laden isotropic turbulence, homogeneous shear flow, fully-developed turbulent channel flow, and turbulent particle-laden round jet. In such flows, the detailed description possible using LES enables in-depth evaluations of statistical and structural features. In particular, the role of inter-particle collision in turbulent channel flow and more recent efforts focused on exploration and analysis of the spatial structure of the particle concentration and velocity fields in homogeneous turbulence are discussed.

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