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RECENT ADVANCES IN KINETIC-BASED MODELS FOR POLYDISPERSE MULTIPHASE FLOWS

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Abstract. Polydisperse multiphase flows are characterized by the presence of a population of particles, droplets or bubbles whose size, density, and other physical properties may vary and evolve in space and time. This population, which constitutes the so-called disperse phase, typically interacts with another phase (carrier phase), exchanging mass, momentum, and energy. Describing the behavior of these flows entails studying the coupled spatio-temporal evolution of the population of entities forming the disperse phase and of the carrier phase. The former requires tracking the changes in space and time of a joint number density function (NDF) of the disperse phase properties (e.g., size, velocity, composition, charge), whose dimensionality, and related computational cost, rapidly increases with the number and complexity of the physical phenomena under consideration (e.g., accounting for particle size and velocity alone leads to a seven-dimensional problem). In order to tackle such dimensionality challenge and maintain an acceptable computational cost for applications, it is possible to directly study the evolution of statistical quantities related to the joint distribution function (NDF) called moments by solving a set of partial differential equations with fluxes and source terms that depend on integrals of the NDF and, consequently, need closures. Quadrature-based moment methods are a robust approach to obtain such closures in the context of Euler-Euler multiphase flow models and offer a systematic procedure to numerically reconstruct the NDF from a vector of its moments. In this lecture, the challenges of describing polydisperse multiphase flows will be introduced by considering gas-liquid and gas-particle flows as examples. Multidimensional quadrature-based moment methods will be discussed in the context of polydisperse multiphase flows. Closure approaches for the moment spatial fluxes and for the source terms in the moment equations that guarantee the preservation of moment realizability will be discussed, as well as coupling strategies to robustly solve the moment equations for the disperse phase together with the equations for the carrier phase. Finally, example results demonstrating the predictive capabilities of the approach using an open-source implementation of quadrature-based moment methods, OpenQBMM, will be shown.

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