Modeling and computation of compressible and incompressible N-phase mixture flows

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ABSTRACT

Modern simulation and modeling approaches for multiphase mixture systems face substantial challenges. These challenges extend beyond computational complexity, reflecting a deeper issue: the absence of a standardized mathematical framework. As a result, existing models struggle to accurately capture the full intricate dynamics of multiphase mixtures, and the connection between various modeling approaches remains unclear.

In this presentation, we introduce a unified modeling and computational framework tailored for both compressible and incompressible N-phase mixture flows. Rooted in continuum mixture theory, this framework derives governing equations and phase-field closure models from first principles. It provides a versatile hierarchy of models, ranging from comprehensive systems of balance laws to simplified yet physically consistent formulations. We analyze this framework by comparing it with existing models through both theoretical and computational perspectives. Finally, we discuss structure-preserving finite element methods and demonstrate their application to benchmark problems in N-phase flow simulations.