Direct Numerical Simulation of Phase Interface motion featuring Complex Interfacial Physics

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Abstract

In recent years, the analysis of multiphase flows involving two-fluid interfacial motion has gained significant momentum across various engineering fields. Early studies primarily focused on the development of numerical algorithms aimed at accurately tracking the interface position between fluids. As a result, numerous computational methods—such as the Volume of Fluid (VOF), Level Set, Front Tracking, Phase Field, and Lattice Boltzmann Methods (LBM)—have been proposed and successfully applied to a wide range of engineering problems. More recently, attention has shifted toward capturing complex interfacial physics beyond the conventional pressure jump induced by geometrical curvature. These efforts include modeling phase change phenomena at the interface, as well as Marangoni flows driven by gradients in temperature or concentration fields. In particular, concentration-driven Marangoni flows become considerably more intricate in the presence of surfactant effects, which alter the local surface tension. This spatial variation in surface tension can, in turn, generate surface viscosity stresses, leading to even more complex interfacial behaviors. This presentation will introduce recent developments in numerical models designed to capture such complex interfacial physics and will provide representative simulation results to highlight their capabilities.

Keywords: Multiphase flow, Interface tracking, Complex interfacial physics, Numerical simulation

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