231b A Lattice-Boltzmann Method for Gas-Liquid Interfaces with Application to the Hindered Rise of Bubbles with Moderate Reynolds Numbers

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We have developed a lattice-Boltzmann boundary method to recover the no-tangential-stress boundary condition at a gas-liquid interface. This rule enables one to use a single-component lattice-Boltzmann solver to simulate gas-liquid flows and thus avoids the challenge of simulating two components with vast density and viscosity differences. A numerical test involving the start-up flow in a liquid film has shown that the method is correct and can accurately account for the unsteady and steady flows near a flat interface.

The method is then applied to flows around spherical bubbles. As the first application, we have studied the rise of a single bubble under gravity. The numerical results have shown that this method can accurately solve both the steady state drag and the unsteady acceleration of spherical bubbles in the Reynolds number range of $0<Re<30$. In the second application, we studied the hindered rise velocity and microstructures of disordered bubble suspensions. The bubbles are monodisperse and non-coalescing. We have observed that the hindered rise velocity (unlike the hindered settling velocity in solid particle suspensions) is not fit well with a power-law. The bubbles in the suspension form a distinctive, non-random structure with strong correlations in horizontal position at all bubble volume fractions, whereas these cross-stream structures are observed only at small volume fractions in solid particle suspensions.