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An interface-preserving and conservative phase-field method for the surface tension dynamics XIAOYU MAO, VAIBHAV JOSHI, RAJEEV JAIMAN, University of British Columbia — We present an interface-preserving and conservative Allen-Cahn phase-field formulation for the modeling of incompressible two-phase flows with surface tension dynamics. To preserve the hyperbolic tangent interface profile, the mobility coefficient is adjusted adaptively as a function of gradients of the velocity and the order parameter in the diffuse interface region in such a way that the free energy minimization properly opposes the convective distortion. In the phase-field formulation, the mass conservation is achieved by enforcing a Lagrange multiplier with both temporal and spatial dependence on the phase-field function. We integrate the interface-preserving and conservative phase-field formulation with the incompressible Navier-Stokes equations and the continuum surface tension force model for the simulation of incompressible two-phase flows. A positivity preserving scheme designed for the boundedness and stability of the solution is employed for the variational discretization using unstructured finite elements. We examine the convergence and accuracy of the Allen-Cahn phase-field solver through a generic one-dimensional bistable diffusion-reaction system in a stretching flow. We quantify and systematically assess the relative interface thickness error and the relative surface tension force error with respect to the convective distortion parameter. Two- and three-dimensional rising bubble cases are further simulated to examine the effectiveness of the proposed model on the volume-preserving mean curvature flow and the interface-preserving capability.

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