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A magnetic field coupling lattice Boltzmann model and its application on the merging process of multiple-ferrofluid-droplet system. (English) Zbl 1462.76209


Summary: The present study concerns the dynamics of ferrofluid droplets in a Newtonian fluid. The incompressible Navier-Stokes (NS) equations are applied for the dynamics of the immiscible magnetic and Newtonian fluids while the Cahn-Hilliard (C-H) equation is adopted to describe the behavior of their interface. A magnetic field coupling lattice Boltzmann (LB) model is developed to solve both the NS equations and the C-H equation. Specially, a mass-correcting term is introduced into the C-H equation, which strongly enforces the mass conservation. The magnetic field is evaluated by a Poisson equation solver with a self-correcting procedure for the static Maxwell equations. The magnetic dipole force is transformed into the magnetic surface force by a rigorous mathematical procedure, which can physically describe the magnetic effect on the interface. Moreover, the magnetic force after this treatment becomes easy-to-implement, which can be directly incorporated into the external force term of the LB model. The capability of the present combination method to simulate the magnetic multiphase flows is demonstrated by three typical numerical examples, i.e., Laplace law for a stationary droplet, a stationary cylinder under an external uniform magnetic field, the deformation of a single ferrofluid droplet. Further, the merging process of multiple-ferrofluid-droplet system in organic oil is investigated. It is found that the elongation of ferrofluid droplet in the direction of magnetic field shows positive impact on the merging process when the orientation of ferrofluid droplets is parallel to the external magnetic field, while negative impact on the merging process when their orientation is perpendicular to the external magnetic field.

MSC:

76W05 Magneto-hydrodynamics and electro-hydrodynamics
76M28 Particle methods and lattice-gas methods
76T10 Liquid-gas two-phase flows, bubbly flows
76D05 Navier-Stokes equations for incompressible viscous fluids

Keywords:

Navier-Stokes equations; Cahn-Hilliard equation; mass-corrected term; magnetic force

Full Text: DOI

References:


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Edited by FIZ Karlsruhe, the European Mathematical Society and the Heidelberg Academy of Sciences and Humanities
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