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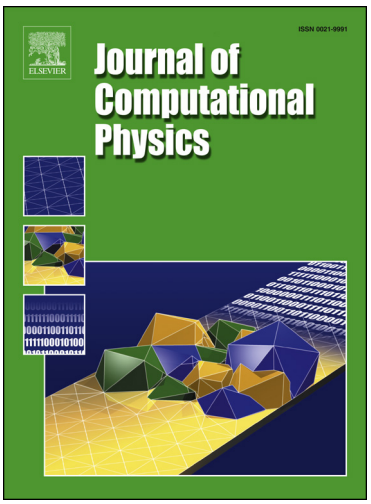

A lattice Boltzmann model for multiphase flows with moving contact line and variable density

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A lattice Boltzmann model for multiphase flows with moving contact line and variable density

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Abstract

In this paper, we develop an efficient lattice Boltzmann model for the two-phase moving contact line problem with variable density. The Navier–Stokes and Cahn–Hilliard equations are recovered from the lattice Boltzmann model proposed by Fakhari and Rahimian [6]. To improve numerical stability, we present a semi-implicit lattice Boltzmann method together with a mixed finite difference scheme. In order to describe the behavior of the contact line motion on the boundary, we incorporate the generalized Navier boundary condition [26] by the nonequilibrium extrapolation method [9]. The proposed method is easy to implement and retains the advantage of the standard lattice Boltzmann method. Numerical tests are carried out to verify the proposed method. Our numerical results show that the present approach is able to model two-phase flows with variable density and moving contact line.

Keywords: Lattice Boltzmann model, variable density, moving contact line, slip boundary condition

1. Introduction

Modelling and simulation of multiphase and multi-component flows have attracted a lot of attentions in recent years. The moving contact line problem, where the fluid-fluid interface intersects the solid wall, is one of the most difficult and important problems that still under intensive investigations. It is well known that the Navier–Stokes equation coupled with no-slip boundary condition will lead to a non-physical singularity near the moving contact line [5]. A phase field model with the generalized Navier boundary condition (GNBC) is proposed in [26] for the moving contact line problem. It is shown that the numerical results based on the GNBC can reproduce quantitatively the results from the MD simulation. The GNBC is also used in different moving contact line problems successfully [22, 34]. Several efficient numerical methods are also developed in recent years for the coupled Navier–Stokes equations and Cahn–Hilliard equation with the GNBC [2, 7, 8, 10].

Recently, the lattice Boltzmann method (LBM) has been developed as an alternative and promising numerical scheme for simulating multiphase and multi-component flows. By tak-