Contribution ID: **569** Type: **Poster Presentation**

A color-gradient lattice Boltzmann model for fluid flow with high density and viscosity ratios

Wednesday, 24 May 2023 10:30 (1h 30m)

Multiphase fluid flows frequently occur in nature and industrial applications including microfluidic devices, enhanced oil recovery, CO2 storage, etc. In order to have a better understanding of multiphase physics, several numerical methods have been developed over the past. The lattice Boltzmann method (LBM) as an alternative to the classical computation fluid dynamic (CFD) method has received much attention due to its favorable features over the classical CFD such as ease of implementation, highly scalable parallelization, and straightforward handling of complex boundaries. In the LBM framework, different models usually fall into four categories; the color-gradient (CG) model, the Shan and Chen (SC) model, the free energy model, and the mean-field model. Among these models, the CG model performs better in conserving mass and since its emergence, it has been advanced to tackle different multiphase physics.

In this paper, a new formulation of the color-gradient method is developed, and a solver based on the lattice Boltzmann (LB) framework is proposed to solve the new formulation. The macroscopic equivalent of the formulation is presented which makes the physical interpretation of the color-gradient easier. In contrast to existing color gradient models where the interface capturing equations are coupled with the hydrodynamic ones and include the surface tension forces, an available LB equation which is capable of handling both high density and viscosity ratios is incorporated to solve the Navier-Stokes equations. Also, unlike previous color-gradient models, the mobility is not related to the density field but instead a constant coefficient.

Two series of numerical tests are conducted to validate the accuracy and stability of the model, where we compare simulated results with available analytical and numerical solutions. In the first set, the interfacial evolution equations are assessed, while in the second set the hydrodynamic effects are taken into account.

Participation

In-Person

References

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Session Classification: Poster

Track Classification: (MS09) Pore-scale modelling