Proceedings of the 9th World Congress on Momentum, Heat and Mass Transfer (MHMT 2024)
London, United Kingdom – April 11 – 13, 2024
Paper No. ICMFHT 155
DOI: 10.11159/icmfht24.155

Hybrid Finite Differences - Lattice-Boltzmann Method for Multiphase Flows: Application to a Jet Simulation

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Extended Abstract

In the past years, Lattice-Boltzmann (LB) solvers have improved a lot and are now considered seriously when fluid dynamics computations are needed. LBM have been studied theoretically and it has been shown that their low dissipation, low relative error, good acoustic properties [1] and high parallelization possibilities are non-negligible assets in the run for high-performance fluid dynamics computations. The quite unstable BGK collision operator has now been replaced by more advanced (recursive) regularized [2] or Multiple Relaxation Times (MRT) kernels; compressible flow simulations have been presented; hybrid (LB / Finite Volume) solvers are efficiently handling combustion [3].

Yet one problem is still really hard to solve with LBM, namely multiphase flows. LBM literature on this topic is quite wide [4], including, e.g. the color-gradient, SC model, free-energy or HCZ methods. The main difficulty is to correctly handle the contact discontinuity in high Reynolds and high density ratios problems.

Our work is based on the phase-field method, which has been giving impressive results recently [5]. The framework is the Diffuse Interface Model (DIM). Liquid and gas are allowed to mix in the interface, whose width is controlled. In addition to the Navier-Stokes-Korteweg system we need to solve an equation for the evolution of the interface. This equation is usually an Allen-Cahn or Cahn-Hilliard equation. In this work, we follow the steps of Shao and Shu [6] who proposed to solve this equation with a finite volume scheme instead of using a second LBM distribution function (which is nearly always the case in the literature), creating a hybrid scheme in the spirit of what have been done for compressible flows [7]. We will show that the resulting scheme is stable even at high density ratios and high Reynolds while being quite flexible, the targeted simulation being a jet flow.

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