Offer of research internship 2026, 6 months
Robust and accurate hybrid multiphase lattice Boltzmann model for incompressible two-phase flow

J. Lu, S. Zhao, and P. Boivin
Aix Marseille Univ, CNRS, Centrale Méditerranée, M2P2, Marseille, France

The modeling of multiphase flow with the hybrid multiphase lattice Boltzmann model[1] is highly efficient; however, it usually suffers from numerical instability at large density ratios, Weber numbers, and Reynolds numbers. Our recent model[2] employs a consistent pressure scheme, high bulk viscosity, and a relatively thick interface width to stabilize the computation, but this approach simultaneously decreases accuracy. This internship will integrate advanced algorithms to enhance the numerical stability and accuracy of the hybrid multiphase lattice Boltzmann model.

THE INTERNSHIP

This internship will focus on developing a more robust and accurate hybrid multiphase lattice Boltzmann model for incompressible two-phase flow, where flow and phase fields are solved by the lattice Boltzmann method and the finite volume method, respectively, based on our recent recursive regularized multiphase lattice Boltzmann model. The lattice Boltzmann model for the flow field has been well established and will be further improved by the supervisor. The internship aims to incorporate a high-order finite volume solver into the existing numerical framework to accurately solve a phase-field equation, i.e., the Allen-Cahn equation

$$\begin{aligned} \partial_t C + \partial_\alpha \left(C u_\alpha \right) &= M \partial_\alpha \left(\partial_\alpha C - \Phi n_\alpha \right), \\ \Phi &= \frac{-4C\left(C-1\right)}{W}, \end{aligned} \tag{1}$$

where the volume fraction of the heavier fluid C is used as the order parameter, Φ is the potential well, W is the specified interface width, M is the mobility coefficient, n_α is the unit vector of the volume fraction gradient.

The internship will be structured around the following objectives:

- Study and implement a basic second-order finite volume solver for the Allen-Cahn equation, and validate the code by simulating some benchmark cases.
- Apply the high-order weighted essentially non-oscillatory (WENO) scheme[3] (both third-order and fifth-order) to discretize the convection term $\partial_\alpha \left(C u_\alpha \right)$.
- Determine the optimal discretization scheme for the diffusion and anti-diffusion terms on the right side of the Allen-Cahn equation, and the general principle of selecting the mobility coefficient.
- Exploration and implementation of the hybrid multiphase lattice Boltzmann model for a simplified engineering case, e.g., 3D jet flow[4].

The internship combines theoretical, numerical, and practical aspects of multiphase flow simulations. It will be carried out at the M2P2 laboratory, as part of the project of the ANR Liberty Industrial Chair.

THE CANDIDATE

You are a final-year student in an École d'Ingénieur or enrolled in a Master 2 program, specializing in fluid mechanics, numerical simulation, or applied mathematics. Basic knowledge of multiphase flows and the finite volume method is required. Experience or a strong interest in programming (Fortran or C++) is an asset, and knowledge of parallel computing paradigms is welcome. Good English communication skills, both spoken and written, are required.

Your CV, cover letter, and grades for the last two years are to be sent to:
pierre.boivin@univ-amu.fr
jinhua.LU@univ-amu.fr

BIBLIOGRAPHY

[1] T. Gregorczyk, S. Zhao, and P. Boivin, "Hybrid lattice boltzmann method for multiphase flows," Physical Review E **112**, 025311 (2025).

[2] J. Lu, T. Gregorczyk, S. Zhao, and P. Boivin, "Phase-field-based recursive regularized multiphase lattice boltzmann model with a consistent pressure scheme," International Journal of Multiphase Flow , 105500 (2025).

[3] C.-W. Shu, "High order weighted essentially nonoscillatory schemes for convection dominated problems," SIAM review **51**, 82–126 (2009).

[4] S. Saito, A. De Rosis, A. Festuccia, A. Kaneko, Y. Abe, and K. Koyama, "Color-gradient lattice boltzmann model with nonorthogonal central moments: Hydrodynamic melt-jet breakup simulations," Physical review E **98**, 013305 (2018).