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Symmetrizing multiphase flow equations for improved accuracy

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When modeling multiphase fluid flows, the summation of the order parameters (or phase-field variables) is equal to unity. This order parameter equation can be used to reduce the number of flow equations by one. This reduction in the number of flow equations is always valid analytically. However, when it comes to numerical modeling, we observe that this reduction leads to different solution depending on which flow equation is removed. Such lack of symmetry is undesirable, and assumed to be a source of inaccuracy. To avoid that the numerical solutions depend on the choice of the reduced set of flow equation, we introduce and investigate solution techniques that preserves the full set of flow equations, thereby removing the lack of symmetry in the numerical solutions. Although we restrict our study to phase-field equations, we believe that the findings are more general.
Two commonly used phase-field equations, namely the Allen-Cahn and the Cahn-Hilliard equation, are solved based on the lattice Boltzmann method. Also, the hydrodynamic equations are also solved with the same method using a recently developed lattice Boltzmann model that can handle both high density and viscosity ratios fluids. In this study we compare the solutions using the reduced set of lattice Boltzmann equations with the solution using the full set of lattice Boltzmann equations. In general, the method solving the full set of equations is not ensuring that the sum of the phase-field variables equals unity. We have therefore also tested a method where this is ensured by an additional error correction step. Our results are compared in terms of accuracy and computational cost. The introduced methods have an additional computational cost, however, we observe improved accuracy at early times.

Participation

In-Person

References

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