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Extended Allen-Chan phase-field equation for ternary fluid flows and phase-change process in binary fluid flows

Thursday, 2 June 2022 15:15 (1h 10m)

Multiphase fluid flows are ubiquitous in many natural phenomena and industrial applications such as oil production, purifying water systems, heat exchangers, etc. Analytical analyses of multiphase flow are limited to simplified cases due to the complex nature of real phenomena. Experiments can reveal main aspects of complex systems, but not concurrently provide detailed information about the individual effects of each involved property or parameter. As computer resources have developed in terms of speed and handling of large data, numerical simulation has received more and more attention and different models have been developed in the field of multiphase fluid flows. Such numerical modeling yields an alternative approach to obtain the physics of multiphase flow on structures of realistic complexity. The most commonly numerical models for interface capturing or tracking may be divided into two categories: sharp-interface models and diffuse interface models such as phase-field models. Phase-field models are mainly used to capture the interfaces between fluids, where the fluid velocity is determined by the Navier-Stokes equations. In general, there are two phase-field theories: Cahn-Hilliard (CH) and Allen-Cahn (AC) [1]. The former includes a fourth-order derivative in its diffusion term, which implies a more complex discretization and a higher dispersion error, while the latter contains only up to a second-order derivative, which makes it more efficient and less dispersive. In spite of the privileges that the AC equation has over the CH, it has received less attention, probably since it was originally proposed for complex interfacial pattern formation process. AC has recently modified to a phase-field model [2], and then reshaped into a conservative form (CAC) [3]. The CAC equation can be solved using conventional CFD models or using lattice Boltzmann method (LBM). Geier et al. [4] were the first to develop a LBM to solve the CAC.
Due the robustness of CAC compared to CH equation, it is of value to extend this equation to simulate ternary fluid flows and also phase-change process in binary fluid flows. In two different works, we extended CAC to handle ternary systems and binary systems with phase-change phenomena, and provided LB models to solve the developed equations. In the first paper [5], for the first time, we extended the CAC from its binary form to ternary systems, and developed a LB model to solve the equation. It was shown that CH-based models are not mass conservative, while the mass conservation does not violate in the proposed ternary CAC. Also, the current ternary CAC enables the elimination of unphysical apparition of one fluid at the interface of the other two fluids, a numerical artifact that exists in the CH-based models. In another paper [6], the CAC is extended to include mass transfer between liquid/vapor phases for modeling phase-change phenomena. Before that, all of the existing phase-field models for modeling the phase-change mechanism were based on the CH equation. Where available, different benchmark tests were conducted, and the results were in good agreement with analytical, experimental, and numerical data.

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Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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