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Phase field-lattice Boltzmann simulations of liquid-solid two-phase flows

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A coupled phase-field-lattice Boltzmann method (PF-LBM) is used for the simulation of liquid-solid two-phase flows. The lattice Boltzmann method (LBM) has been used as a numerical tool for predicting fluid flows due to its computational advantages related to parallel computing. On the other hand, the main feature of the phase field model (PFM) is the formulation in terms of an order parameter which gradually changes and defines the phase of the system. Since LBM and PFM use Cartesian grids for flow prediction, a combination of these two methods is suitable for solving problems with phase transformation. The governing equation of the fluid flow is given by the lattice Boltzmann equation with external forces which incorporate the effects of the liquid-solid transition depending on the phase field, e.g. the no-slip boundary conditions at a diffuse interface. The liquid-solid interaction is defined by the time evolution of the phase field including the effects of moving boundaries. Initially, two benchmark problems with stationary boundaries have been used for validation of the method, i.e. Poiseuille flow and flow past a circular cylinder. The results confirm that the no-slip boundary condition is well satisfied at the diffuse interface. Then, the simulation of a solidification problem is carried out to analyse the influence of fluid flow on the solidification process. The results are compared with available analytical solutions.

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