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Volume of Fluid based study of the three phase dynamic contact line in the wetting of a thin channel.

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A continuum sharp-interface modelling of the molecular motion in the vicinity of the three-phase dynamic contact line is a significant research problem [1] having extensive practical relevance [2]. It is a prerequisite to full pore-scale Direct Numerical Simulation (DNS) with a high-fidelity representation of dynamic wetting phenomena. To investigate the three-phase dynamic contact line in the wetting of small pores, we numerically design a setup consisting of a pressure gradient-driven two-phase flow inside a thin channel (width ~ 0.1 - 10μm). The two phases are separated by an interfacial layer with surface tension, that meets the pore wall, hence, a three-phase dynamic contact line is formed. This setup is then studied numerically by solving the planar two-phase Navier-Stokes equations, comparing three contact-line boundary conditions: the Navier-slip boundary condition, the super-slip boundary condition and the generalized Navier boundary condition (GNBC). We use the Basilisk flow solver to do Volume-of-Fluid (VOF) based simulations with the surface tension force computed using the Continuous-Surface-Force method and curvature calculations using the Height-Function method. Steady-state solutions are found for all three boundary conditions and a critical capillary number is predicted beyond which no steady-state solution exists. We thus extend previous contact line modelling using the VOF method [3],[4]. Similar to [3], we see that the Navier-slip model with a constant microscopic contact angle is weakly singular. This singularity does not prevent the prediction of the critical capillary number for wetting. The advantage of this new setup over the previous "hydrodynamic assist"setup of [2] and [3] and the "sheared droplet"setup of [1], is its direct relevance to the DNS at small pore size and the opportunity to reduce the range of scales involved. Due to the quadtree adaptive mesh refinement (AMR) and parallel-processing capabilities of our code, a parametric study with realistic nanometric slip length is possible and interesting flow features and scaling laws are discovered in the vicinity of the contact line.

Participation

In-Person

References

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