Two-phase capillary flow through undulating tube

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We study the drainage of a wetting fluid in a two-dimensional undulating capillary tube using the lattice Boltzmann method [1,2]. The method is modified in order to allow constant contact angle on the walls. The walls of the tube are given by sinusoidal functions. This tube acts as a simplified model of a two-dimensional fracture geometry and allows us to test the applicability of the lattice-Boltzmann method and gain insight into the dynamical aspects of capillary flow through natural fractures. The fluid starts at rest and the non-wetting fluid is injected into the tube from one end. We apply a constant pressure difference between the inlet and the outlet. This pressure difference is large enough to overcome the capillary forces even at the most narrow parts of the tube. The results are compared against quasistatic predictions given by the Washburn equation. For low driving forces the Washburn estimate of the velocity is followed and the interfacial pressure drop is given by the radius of curvature of the interface. We study the transition from quasistatic to dynamic flow. We plan to extend these studies to drainage in rough fractures.

[1] D. Rothman and S. Zaleski, *Lattice Gas Cellular Automata*, Cambridge University Press, Cambridge (1997).

[2] Y. Qian, D. d'Humières, P. Lallemand, Europhys. Lett. **17**, 479 (1992).