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DIFFUSE-INTERFACE MODELS FOR WETTING AND MOVING CONTACT-LINE PROBLEMS

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A contact line occurs when an interface between two immiscible fluids is intersected by a smooth solid surface. Wetting of a solid surface is reflected by motion of the contact line. The motion of contact lines is important in a large number of applications including coating, lubrication, surface cleaning and printing processes. Much effort has been devoted to analyses of contact-line motion. However, precise analyses are challenging, both conceptually and numerically, due to the multiscale character of the moving contact-line phenomenon. Sharp-interface models in combination with standard no-slip conditions result in the so-called contact-line paradox, by which the motion of the moving contact line is impeded by the no-slip condition. The paradox is resolved by a stress singularity in the vicinity of the contact line [1]. Analytical models of this phenomenon have limited predictive capabilities in terms of, for instance, spreading rate. Numerical models are impaired by the sensitivity of the contact-line motion to the stress singularity.

Among models introduced to regularize the singularity at the contact line, diffuse-interface models such as the Cahn-Hilliard Navier-Stokes (CHNS) [2,3] equations provide a suitable basis for studying interfacial and contact-line motion. Numerical approximation of the CHNS equations is complicated, however, in view of the necessity to resolve thin layers, and to maintain energy dissipation in the spatial and temporal discretizations. These complications become even more pronounced in the presence of exogenous volumetric forces, like gravity, and in the case of significant density differences between the two fluids. Moreover, investigation of the contact between the two-phase fluid and solid substrate requires the implementation of appropriate boundary conditions, which generally carry their own parameters and length and time scales [4].

In this presentation we consider numerical approximation of the coupled CHNS model for simulation of wetting behavior of incompressible two-fluid systems. Aspects related to stability, accuracy and iterative-solution techniques will be treated.

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