A Monolithic Adaptive Isogeometric Analysis Approach to Elasto-Capillary Fluid-Solid Interaction

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ABSTRACT

Binary fluids are fluids that comprise two constituents, viz. two phases of the same fluid (gas or liquid) or two distinct species (e.g. water and air). A distinctive feature of binary-fluids is the presence of a fluid–fluid interface that separates the two components. This interface generally carries surface energy and accordingly it introduces capillary forces. The interaction of a binary-fluid with a deformable solid engenders a variety of intricate physical phenomena, collectively referred to as *elasto-capillarity*. The solid–fluid interface also carries surface energy and, generally, this surface energy is distinct for the two components of the binary fluid. Consequently, the binary-fluid–solid problem will exhibit wetting behavior [1,2]. Elasto-capillarity underlies miscellaneous complex physical phenomena such as *durotaxis* [3], i.e. seemingly spontaneous migration of liquid droplets on solid substrates with an elasticity gradient; *capillary origami* [4], i.e. large-scale solid deformations by capillary forces. Binary-fluid–solid interaction is moreover of fundamental technological relevance in a wide variety of high-tech industrial applications, such as inkjet printing and additive manufacturing.

In this presentation, we consider a computational model for elasto-capillary fluid-solid interaction based on a diffuse-interface model for the binary fluid and a hyperelastic-material model for the solid. The diffuse-interface binary-fluid model is described by the incompressible Navier–Stokes–Cahn–Hilliard equations [5] with preferential-wetting boundary conditions at the fluid-solid interface. To resolve the fluid-fluid interface and the localized displacements in the solid, we apply adaptive hierarchical B-spline approximations. A monolithic solution scheme is applied to enable robust solution of the coupled FSI problem. We consider several aspects of the formulation and of the simulation techniques. To validate the presented complex-fluid-solid-interaction model, we present numerical results and conduct a comparison to experimental data for a droplet on a soft substrate [6,7,8].

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