Interaction of solids and complex fluids.

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ABSTRACT

Fluid-Structure Interaction (FSI) models [1] have traditionally focused on the interaction of solids with classical fluids governed by the Navier-Stokes equations of incompressible or compressible flows. However, there are a number of open FSI problems which depend on physical mechanisms that cannot be captured by the Navier-Stokes equations alone. Prime examples are fluid-solid problems that involve multi-phase and/or multi-component flows such as, durotaxis, capillary origami or phase-change-driven implosion. Here, we present our initial steps toward complex fluid-structure interaction modeling. The structure is treated as a hyperelastic solid governed by the equations of nonlinear elastodynamics. To describe the behavior of the complex fluid, two different diffuse-interface approaches are adopted. The first one is based on the Navier-Stokes-Korteweg equations [2, 3], which describe single-component two-phase flow and naturally allow for phase transformations in compressible fluids. We use this model to condensate droplets on a soft solid and show that droplet motion may be driven by stiffness gradients -durotaxis- and strain gradients -tensotaxis- of the underlying substrate. We also show several problems of phase-change-driven implosion, in which a thin structure collapses due to the condensation of a fluid. The second complex-fluid model is based on the Navier-Stokes-Cahn-Hilliard equations [4], which describe two-component immiscible flows with surface tension. The potential of this model is illustrated by solving several elasto-capillary problems.

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