Parametric finite element approximation of two-phase Navier–Stokes flow with viscoelasticity

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In this talk, we present a parametric finite element approximation of two-phase Navier–Stokes flow with viscoelasticity. The free boundary problem is given by the viscoelastic Navier–Stokes equations in the two phases, which are connected with jump conditions across the interface. The elasticity in the fluids is described with the Oldroyd-B model for the left Cauchy–Green tensor associated with the elastic part of the total mechanical response of the material, where we allow possible stress diffusion. The model was originally introduced to approximate fluid–structure interaction problems between an incompressible Newtonian fluid and a hyperelastic neo-Hookean solid, which are possible limit cases of the model.

We approximate a variational formulation for the mean curvature of the interface and for the interface evolution with a parametric finite element method. The two-phase Navier–Stokes–Oldroyd-B system in the bulk regions is discretized in a way that unconditional solvability and stability for the coupled bulk–interface system are guaranteed. Moreover, we show that the discrete Cauchy–Green tensor is positive definite. Good volume conservation properties for the two phases are observed in the case where the pressure approximation space is enriched with the help of an XFEM function. In the end, we show the applicability of our method with numerical results.

Keywords: Finite elements, XFEM, two-phase flow, viscoelasticity, Oldroyd-B, free boundary problem, interface