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Numerical simulation of multiphase flows with incompressible viscoelastic flows and elastic solids

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A numerical model for the simulation of multiphase flows with free surfaces is presented. The model allows to incorporate in a unified manner several phases ranging from incompressible Newtonian flows, Oldroyd-B viscoelastic flows and neo-Hookean elastic solids.

We advocate an Eulerian modeling of the multiphase flows, relying on a volume-of-fluid (VOF) method, describing multiple phases with different rheologies. One advantage of the Eulerian approach is to allow for large deformations of elastic solids. The numerical framework relies on an operator splitting strategy and a two-grid method.

The operator splitting strategy allows to decouple the transport operators from the diffusion problems. The space discretization relies on a structured Cartesian grid, and an unstructured finite element mesh. The prediction step allows to solve the transport equations with a method of forward characteristics on the Cartesian grid. This prediction is corrected in a second step by solving a Stokes problem, and an Oldroyd-B problem without advection terms using low order piecewise linear finite elements.

The numerical model is validated with several numerical experiments. We focus on interactions between elastic solids and Newtonian or visco-elastic fluids, and present results ranging from machining industrial processes to collisions between elastic solids.

This is a joint work with Léo Diserens, and Prof. Marco Picasso (EPFL).