Numerical simulation of several interacting viscoelastic flows with free surfaces

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A unified numerical framework is presented for the modelling of multiphasic visco-elastic and elastic flows with free surfaces. The rheologies range from incompressible Newtonian or Oldroyd-B viscoelastic fluids to Neo-Hookean elastic solids. The model is formulated in Eulerian coordinates. The unknowns are the volume fraction of each phase (liquid, viscoelastic or solid), the velocity and the stress of each phase.

A time splitting strategy is applied in order to decouple the advection operators from the diffusion operators. The numerical approximation in space consists in a two-grid method. The advection equations are solved with a method of characteristics on a structured grid of small cells and the diffusion step uses an unstructured coarser finite element mesh. Stability estimates are proved for a linear model problem.

The model is validated through several test cases. Simulations of collisions between Neo-Hookean elastic solids is explored. The simulation of the fall of an immersed Neo-Hookean elastic solid or an Oldroyd-B viscoelastic fluid into a Newtonian fluid is also presented.

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