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A Space-Time Cut Finite Element Method for Navier-Stokes equations

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We present a space-time Cut Finite Element Method (CutFEM) for the Navier-Stokes equations involving two immiscible incompressible fluids with different viscosities, densities, and with surface tension. We have extended the cut finite element method developed for the Stokes interface problem in [1] to the Navier-Stokes equations using the space-time strategy proposed in [2].

Our CutFEM yields accurate approximations of the pressure, which may be discontinuous, and the velocity field, which may have a kink across the evolving interface, without requiring the mesh to be conformed to the interface. Thus, remeshing processes, which easily become cumbersome when topological changes such as drop-breakup or coalescence occur, are avoided. We use a fixed background mesh of the computational domain and continuous elements in space and discontinuous elements in time. The interface conditions are enforced weakly using a variant of Nitsche's method. Stabilization terms are added in the variational formulation that ensure well-conditioned linear systems independently of the position of the interface relative to the fixed background mesh. For the representation and evolution of the interface we use a level set method but other interface representation techniques can also be used.

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