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MULTIPHASE FLOWS WITH SURFACE TENSION AND CAPILLARITY

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ABSTRACT

Surface tension acts at the interface of two immiscible fluids, leading to the minimization of the contact area. This quantity is therefore of primary importance in a wide range of phenomena determining, for example, the shape, breakdown or coalescence of droplets or bubbles. Consequently, it is a crucial parameter for understanding, modelling and simulating many industrial processes. Furthermore, when a third phase is considered like a solid substrate, capillary effects appear at the triple junction, acting as an additional driving force. Among other things, these effects control the behaviour of a droplet on a solid surface, or a liquid against a wall, and play an important role in many natural or industrial processes.

From the point of view of computational mechanics, surface tension and capillarity are problematic in a large number of ways. Basically, a simulation with surface tension must be stable, efficient and accurate: parasitic currents are under control, the time step is not drastically constrained by spatial discretization, and a "good" coupling is ensured between the fluid mechanics problem and the interface geometry. Fulfilling these criteria requires making several choices when elaborating the numerical strategy. First, the moving fluid-fluid interface must be accurately described. This is generally achieved by using Level-Set or Volume-Of-Fluid approaches. However, the surface tension term depends on the mean curvature (Laplace’s law), given by the second-order derivatives of the surface parameterization. Several options exist to calculate this term: a nodal projection of first-order derivatives, a higher order approximation of the function describing the interface, … Second, by definition, the surface tension is specified on an interface, *i.e.* on a manifold of dimension

d-1, *d=2* or *d=3*. This can be done in two ways: either by transforming the surface term into a volume term using a smoothed Dirac's delta (CSF), or by locally reconstructing the interface using the *Level-Set* function, for example. Finally, the jump in fluid properties (*e.g.* viscosity and density) at the interface induces a discontinuity in the pressure gradient, while the pressure is discontinuous due to the curvature. Depending on the choice made to impose the surface force, different strategies can be defined and combined to treat these weak and strong discontinuities: smoothing the material properties, enriching locally the quadrature rules, adapting the mesh, enriching the approximation spaces (E-FEM, X-FEM), …

The objective of this mini-symposium is to provide a review of the latest advances in the computational mechanics community in the modelling and simulation of flow involving surface tension. Of course, the points listed above are not exhaustive, and all contributions on the subject are welcome. Furthermore, considering a third phase, *e.g.* a solid substrate, implies an additional complexity: the description of the interface between these phases (triple junction). This results in capillarity and wetting phenomena.