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Thermo-Capillary Flow using the Smoothed Particle Hydrodynamics (SPH) Method

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Lagrangian discretisation methods have advantages in dynamics of complex multi-phase systems because the interface position is tracked implicitly and mass is conserved. One example for a particle-based Lagrangian method is the Smoothed Particle Hydrodynamics (SPH) method. Introduced in 1977 for astrophysical problems, the method gained popularity in the 1990s for engineering problems in fluid dynamics and in the 2000s for multi-phase problems, especially when free surfaces are present [1].

In this work we introduce an SPH model for multi-phase systems where thermal convection effects are dominant and surface tension forces are temperature-variant. We first validate the momentum balance of the proposed model and its discrete formulation starting with the very common isotherm lid-driven cavity test case to demonstrate accurate implementation of the momentum balance, boundary conditions and numerical stability approaches. Afterwards we couple the momentum equation with the energy equation and consider a buoyancy-driven flow in a cavity where the density of the fluid is temperature-dependent.

We discuss the formulation of surface tension including temperature-dependent gradients of the surface tension tangential to the interface and highlight features of the discretisation using a spherical droplet and a planar interface with tangential temperature gradient. Finally we consider the complete model to investigate thermo-capillary flow. We consider the migration of a spherical droplet [2] and investigate the stationary migration velocity. Numerical convergence is shown by comparison to reference simulations taken from literature.

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