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Numerical simulations of two-phase systems using the Phase Field method

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In this work, we implement a two-phase solver that is based on a diffuse interface approach, known as the Phase Field method and assess its performance in a range of test cases. The two-phase solver is built on top of an in-house single-phase solver, which is based on an implicit finite-volume method [1] and is appropriate for viscoelastic fluids. The numerical investigation of the two-phase flow field is achieved by solving the conservation of mass, the momentum and the stress-constitutive equation together with the convective Cahn-Hilliard equation [2], which is responsible for distinguish the transport of each phase. In contrast to sharp interface approaches, here, the interface between the two fluids adopts a continuum approach which is responsible for smoothing the inherent discontinuities [3]. Therefore, studies that are related to morphological changes of the interface, such as droplet breakup and coalescence, are feasible [4].

In order to evaluate the efficiency of the numerical implementation several problems such as the Rayleigh-Taylor instability, the oscillation of a square droplet, the rising bubble and the deformation of a droplet under constant shear are investigated. For all these cases the two-phase solver manages to predict the expected dynamics and presents an overall good performance. Especially for the case of the Rayleigh-Taylor instability which presents the most complex interfacial patterns among all the investigated cases, our implementation demonstrates a very good performance managing to capture both qualitatively (complex concentration patterns) and quantitatively (positions of the moving fronts) the behaviour of the interfacial instability.

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