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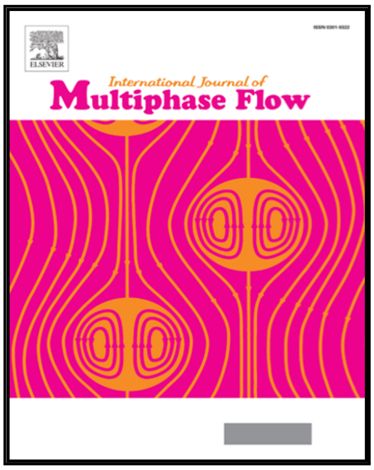

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Mass conservation and reduction of parasitic interfacial waves in level-set methods for the numerical simulation of two-phase flows: a comparative study

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Abstract

A commonly used class of methods for the numerical simulation of two-phase flows is level set. It is often reported though that this method does not accurately conserve mass of each fluid, unlike other interface capturing techniques such as volume-of-fluid. A further concern besides mass conservation is the formation of any parasitic currents. Since the initial formulation of level-set methods, however, numerous modifications have been proposed, and it does not seem clear whether mass conservation errors and parasitic currents are problematic for all of these and, if not, what key steps could be taken to avoid them. Furthermore, results reported in the literature are often for benchmark tests in two dimensions, and it is not clear whether a good performance there holds up in three dimensions. We undertake here a comparative study, reporting test results in two and three dimensions for various level-set methods on a variety of problems. Kinematical tests are first performed for prescribed velocity fields, followed by benchmark tests including the solution of the Navier-Stokes equations. It is shown that higher-order schemes for spatial and temporal discretization may improve mass conservation and avoid interface distortion. In particular, two reinitialization methods that are straightforward to implement perform very well at all these tests. It is demonstrated that some schemes introduce parasitic oscillations in the simulation of Rayleigh-Taylor instability.

Keywords: Level-set method, Reinitialization, Mass conservation, Parasitic currents

1. Introduction

Level-set methods are widely used for the numerical simulation of two-phase flows (see for instance, Osher & Fedkiw (2003)). In these, as in other interface-capturing methods such as volume-of-fluid and diffuse-interface methods, interfaces are evolved through a scalar field that is defined

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