State-of-the-Art Finite-Volume Discretisation of Kapila's Two-Fluid Flow Model

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Key Words: *two-fluid model, finite-volume method, higher-order accuracy, positivity preserving time integrators, wave impacts, sloshing*

In preparation of the study of liquefied natural gas (LNG) sloshing in ships and vehicles, we model and numerically analyze compressible two-fluid flow. The fluids are assumed to be inviscid and immiscible. Further, heat conduction, phase changes and chemical reactions are still absent. We use the five-equation two-fluid flow model introduced by Kapila et al. [1]. The model consists of two systems of conservation laws, which have been reduced and merged by the assumption that velocity and pressure are continuous across two-fluid interfaces. The model requires an additional equation to track the interfaces, which we do in terms of the *volume-of-fluid fraction,* indicating the relative presence of one of the two fluids in the local mixture.

The Kapila system of partial differential equations is hyperbolic and quasi-conservative. It is discretised in space with a tailor-made third-order accurate finite-volume method, employing an HLLC approximate Riemann solver. The third-order scheme is obtained through spatial reconstruction with a limiter function to prevent spurious oscillations, for which some novel formulations are presented. The non-homogeneous term in the equation for the two-fluid interface is handled in a way consistent with the HLLC method. An explicit third order Runge-Kutta time integrator is used, which is positivity preserving, as is the HLLC method.

We study the one-dimensional case of a liquid column impacting on a gas pocket entrapped at a solid wall. This is known as the generalized Bagnold problem [2]. It mimics the impact of a breaking wave in an LNG containment system, where the gas pocket is entrapped at the tank wall below the wave crest. Furthermore, the impact of a shock wave on a gas bubble immersed in air is simulated, in two dimensions, and compared to experimental results [3]. Two cases are considered, one where the bubble gas is heavier (R22), and one where it is lighter (Helium) than the ambient air. The computational results are consistent with the experimental results.

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