Numerical Simulation of Cavitation Bubbles by Compressible Two-Phase Fluids

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ABSTRACT

The present work deals with the numerical investigation of collapsing cavitation bubbles in compressible fluids. Here the fluid of a two-phase vapor-liquid mixture is modeled by a single compressible medium. This is characterized by the stiffened gas law using different material parameters for the two phases.

For the discretization of the stiffened gas model the approach of Saurel and Abgrall [1] is employed where the flow equations, here the Euler equations, for the conserved quantities are approximated by a finite volume scheme and an upwind discretization is used for the non-conservative transport equations of the gas fraction by which the different phases are indicated. The original 1st order discretization is extended to higher order applying 2nd order ENO reconstruction to the primitive variables. The derivation of the non-conservative upwind discretization for the gas fraction is presented for arbitrary unstructured grids.

The efficiency of the numerical scheme is significantly improved by employing local grid adaptation. For this purpose multiscale-based grid adaptation [2,3] is used in combination with a multilevel time stepping strategy [4] to avoid small time steps for coarse cells.

The resulting numerical scheme is first applied to the collapse of a spherical bubble. The results are compared with recent experimental data. Next we consider the planar collapse of a vapor bubble near to a rigid wall [5]. These computations reveal new insight to the mechanism of the bubble collapse and the formation of a liquid jet penetrating the bubble and hitting the wall. The impact of the jet causes a high pressure load to the wall that can cause severe material damage.

This is joint work with Philippe Helluy (Strasbourg) and Josef Ballmann, Mathieu Bachmann (Aachen).

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