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 Abgrall and Saurel 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 pressure law coefficients. 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 phase indicator, here 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 is used in combination with a multilevel time stepping strategy to avoid small time steps for coarse cells. The resulting numerical scheme is then applied to the numerical investigation of the collapse of a vapor bubble in a free flow field and near to a rigid wall.

1 Introduction

The formation of vapor bubbles in a liquid is called cavitation. The bubbles may grow or collapse. Lord Rayleigh discovered that pressure waves emitted during processes of cavitation [Ray17] may damage solids, e.g., ship propellers. However, the mechanisms causing the damage of the solid are far from being completely understood.

Cavitation is induced by a pressure drop in the liquid below vapor pressure. Such a pressure decrease may occur due to local acceleration of the liquid flow caused by geometrical constraints, e.g., if the liquid flows through a narrow

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