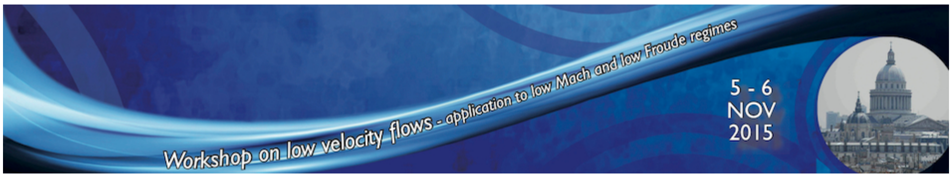

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A preconditioned Roe-type scheme for a two-phase compressible flow model at low Mach number

We describe two-phase compressible flows by a hyperbolic six-equation single- velocity two-phase flow model with stiff mechanical relaxation. In particular, we are interested in the simulation of liquid-gas mixtures such as cavitating flows, which are relevant in numerous engineering devices. The model equations are numerically approximated via a fractional step algorithm, which alternates between the solution of the homogeneous hyperbolic portion of the system through wave propagation finite volume schemes, and the solution of a system of ordinary differential equations that takes into account the pressure relaxation terms. When used in this algorithm, classical schemes such as Roe's or HLLC prove to be very efficient to simulate the dynamics of transonic and supersonic flows. Unfortunately, these methods suffer from the well known difficulties of loss of accuracy and efficiency for low Mach number regimes encountered by upwind finite volume discretizations. This issue is particularly critical for liquid-gas flows due to the large and rapid variation of the Mach number, since the speed of sound may range from very low values in the two-phase mixture to very large values in the liquid medium. To cure the problem of loss of accuracy at low Mach number, in this work we extend to the considered two-phase flow model the strategy of the preconditioned Roe-Turkel scheme of Guillard–Viozat for the single-phase Euler's equations. A suitable set of entropic variables for the two-phase system is chosen to define the Turkel-type preconditioning matrix that corrects the numerical dissipation term of the finite volume scheme at low Mach number. As for the single-phase case, the resulting technique alters only the acoustic characteristic fields of the model at low Mach number, while interface (contact) waves are preserved unchanged. We present numerical results for two-dimensional liquid-gas channel flow tests that show the effectiveness of the proposed preconditioned method for the two-phase system. In particular, we show that in the low Mach number limit pressure perturbations at the discrete level correctly scale with the square of the reference Mach number, in agreement with the theoretical results for the continuous two-phase flow model. Preliminary numerical experiments for problems involving liquid-vapor transition for the full model with heat and mass transfer terms will be also presented.

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