A Compressible Two-Fluid Flow Method. Application to Shock-Bubble Interactions

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Multi-fluid flows are found in many applications: flows of air and fuel droplets in combustion chambers, flows of air and exhaust gases at engine outlets, gas and petrolea flows in pipes of oil rigs, water-air flows around ship hulls, etc. To gain better insight in the behavior of multi-fluid flows, especially two-fluid flows, numerical simulations are needed.

We assume that the fluids do not mix, but remain separated by a sharp interface. With this assumption a model is developed for unsteady, compressible two-fluid flow, with pressures and velocities that are equal on both sides of the two-fluid interface. The model describes the behavior of a numerical mixture of the two-fluids (not a physical mixture). This type of interface modeling is called interface capturing. Numerically, the interface becomes a transition layer between both fluids.

The model consists of five equations: the mass, momentum and energy equation for the mixture (the standard Euler equations), the mass equation for one of the two fluids and an energy equation for the same fluid. In the latter, a novel model for the energy exchange between both fluids is introduced. The energy-exchange model forms a source term.

The spatial discretization of the model uses a monotone, higher-order accurate finite-volume approximation, the temporal discretization a three-stage Runge-Kutta scheme. For the flux evaluation a Riemann solver is constructed. The source term is evaluated using the wave pattern found with the Riemann solver.

The two-fluid model is validated on several shock-tube problems and on two standard shock-bubble interaction problems.