Resolution of vorticity field at density discontinuity in numerical simulation of multicomponent flows

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ABSTRACT

The examples of turbulent mixing of multi-component or multiphase flows resulting from Richtmyer-Meshkov instability (RMI) can be observed in inertial confined fusion, astrophysics and supersonic combustion. The instability happens in the shock accelerated inhomogeneous compressible flows and is driven by the baroclinic vorticity generation. The interaction of a shock wave with an isolated gas bubble of variable density can be treated as convenient configuration to study RMI induced mixing on a fundamental level.

To study this problem we have applied multi-component Eularian type flow equations and we have developed numerical procedures for the solution of hyperbolic system of governing equations with non-conservative terms. Instead of using only mixture thermodynamic variables the model treats each fluid with its own density and pressure. Therefore it has the ability to use different equations of state and hence different heat capacity ratios for individual flow components. The numerical solution based on a finite volume Godunov type computational technique equipped with an approximate Riemann solver for calculating fluxes accounts for pressure non-equilibrium and enables the resolution of flow component interfaces [1]. It can naturally handle complex fluid interfaces. The same solution technique is implemented in the regions of pure fluids as well as in diffused mixture zones. The numerical results demonstrate the efficiency of the new approach for various initial conditions promoting a shock-bubble interaction. These are presented for different parameters related to the initial flow topology of the heterogeneous media, their constituents Atwood number and shock wave Mach number. The numerical results illustrate characteristic features of evolving interfaces. The impulsively generated flow perturbations are dominated by refraction and refraction of the shock and vorticity generation within the media.

REFERENCES

[1] Nowakowski, A.F., Ballil, A and Nicolleau, F.C.G.A. Passage of a shock wave through inhomogeneous media and its impact on gas-bubble deformation. *Phys. Rev. E*, Vol. **92**, 023028, (2015).