Numerical Simulation of Stratified Richtmyer-Meshkov Instability with Global ALE Method

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Richtmyer-Meshkov(RM) instability[1] arises when a material interface is accelerated impulsively by shock waves. It plays an important role in many fields, such as ICF, supernova and so on. In this work, a novel arbitrary Lagrangian-Eulerian method, global ALE method (GALE), was developed for stratified RM instability.

Unlike traditional ALE methods[2], where rezoning and remapping are performed just in the internal of one material region, and material interfaces are tracked by Lagrangian mesh lines, the GALE method attempts a compromise by combining the merits of both ALE and Eulerian methods. In the GALE method, modern Eulerian methods, such as mass fraction model, level set method, are coupled with a Godunov-type ALE method. Thus all the meshes can be moved arbitrarily no matter whether they are material interface or not. In the simulation of multi-material flows using GALE, Lagrangian or Eulerian interface treatment can be selected according to the degree of interface distortion or other standard. Some benchmark problems, such as gas-liquid shock tube problem, RM instability with small initial perturbation in planar geometry, were computed by the GALE to verify the method, and the numerical results agree well with exact solution or theoretical model.

The previous numerical studies for RM instability are mainly performed in the case with single interface in plane geometry by Eulerian methods. In this work the GALE method was used to simulate the stratified RM instability with two or more material interfaces in planar, cylindrical and spherical geometries. The unperturbed interface was tracked in Lagrangian mode and the perturbed interface was captured in Eulerian mode by mass fraction model. The interface evolution process was studied and compared in different geometry cases based on simulation results. As shown in Fig.1, the spikes in planar and cylindrical geometries are narrower and longer than those of spherical case, and the roll-up of spikes seems more manifest. These discrepancies can be contributed to the stronger implosive compressibility in converged geometry. More detailed analysis will be made in the future work.

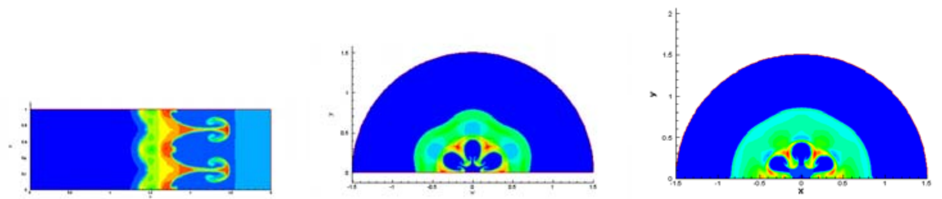

Figure 1: Stratified RM instability in planar, cylindrical and spherical geometry.

References

[1] M. Brouillette, *Annu. Rev. Fluid Mech.*, **34,** 445(2002).
[2] D. J. Benson, *Comput. Methods Appl. Mech.* Eng. **99,** 235 (1992).