Two-dimensional simulations of Rayleigh-Taylor instability in planar, cylindrical, and spherical geometries

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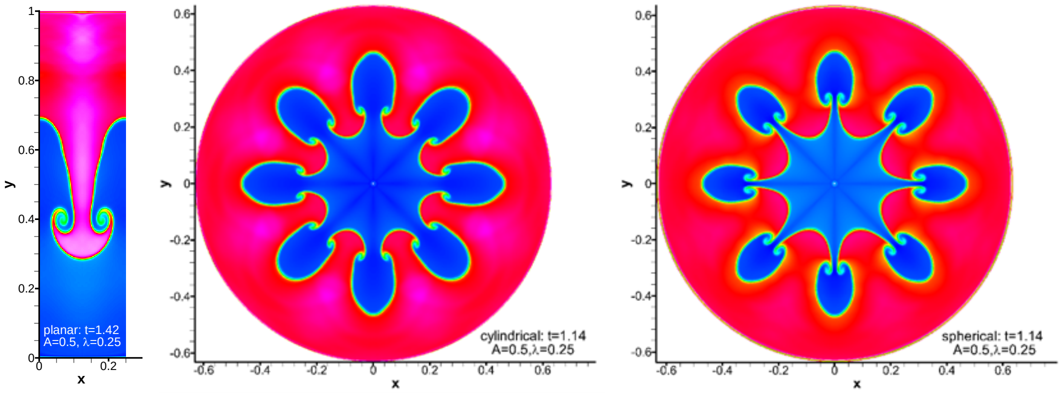
The Rayleigh-Taylor instability (RTI) [1,2] occurs at a disturbed interface of unequal-density fluids when a lighter fluid is accelerated into a heavier fluid or a lighter one supports a denser one against gravity. The RTI plays a critical role in a wide range of natural phenomena and applications, including supernova explosions [3] and inertial confinement fusion (ICF) [4]. The current ignition for ICF experiments performed at the National Ignition Facility has not yet been achieved, because the RTI regarded as a major factor in the ICF implosions brings cold fuel from the outer layer into the centre "hot spot", lowering the temperature and decreasing the thermonuclear reaction rate [5]. Most numerical studies of RTI are performed primarily in planar geometry, whereas the actual ICF targets are spheres, which are associated with the convergence effects. Thus, the RTI in spherical and cylindrical (at reduced levels) geometries should be quite different from the planar cases.



(a) planar (b) cylindrical (c) spherical

Figure 1: Two-dimensional numerical results of the compressible Rayleigh-Taylor instabilities with the same Atwood number $A = 0.5$ and wavelength $\lambda = 0.25$ in planar, cylindrical, and spherical (rotationally symmetrical) geometries.

Three dimensionless results for RTI with a single-mode perturbation in planar, cylindrical and spherical geometries are displayed in figure 1. It shows that the stronger converging geometries, the wider "spikes" (red) and smaller "bubbles" (blue) are the material interfaces, which indicates that the convergence effects are significant for the assessment of RTI in ICF implosions.

References

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