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The Richtmyer-Meshkov instability in cylindrical geometry: Experiments and simulation

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Hydrodynamic instabilities are fundamentally important to a wide range of fields, including astrophysics, inertial confinement fusion (ICF), and inertial fusion energy (IFE). The most common of these instabilities is the Rayleigh-Taylor (RT), or buoyancy-driven instability, is caused when a material of higher density is accelerated by a material of lower density. The Richtmyer-Meshkov (RM), or shock-driven instability is produced when an incident shock wave impulsively accelerates a material interface causing small disturbances to grow.

The RT interface is unstable only when the external force acts from the heavy material to the lighter material, whereas the RM instability is present whether the incident shock travels from light to heavy or vice versa. The majority of the theoretical, computational and experimental work has been successfully performed for the RM instability in planar geometry. In most physical applications the RM instability occurs in a curved geometry, either cylindrical or spherical. This curved geometry complicates the system considerably. For example, the unperturbed system does not have an analytical solution, while the unperturbed system in plane geometry does. The occurrence of re-acceleration or re-shock of the material interface caused by the waves reflecting back from the origin is unavoidable in curved geometry.

The Nova Laser was used to test critical ingredients of our understanding of the fundamental properties of the RM instability in the strong-shock, high-compression regime. A shock was launched into a copper hemicylinder with a thin plastic ablator layer by focusing 6 KPP-smoothed, 1 ns square laser beams at 3ω onto the interior of the target. A single-mode sinusoidal perturbation was machined onto the outer surface of the copper, which was embedded in a thick layer of plastic. The expanding interface was diagnosed by side-on radiography and radiographs were recorded at several times.

We will show numerical simulations of this experiment using two difference codes: FronTier and CALE. In the FronTier method a lower dimensional grid is fitted to and moves dynamically with discontinuities in the flow. CALE is a continuous adaptive Lagrangian Eulerian method.

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