Multimode Simulations of the Richtmyer–Meshkov Instability Using DRACO


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Summary

Richtmyer–Meshkov instability can play an important role in the deceleration phase of an ICF implosion

- The shell of an imploding ICF capsule is decelerated by a series of reflected shocks.
- These shock interactions with the perturbed shell can cause Richtmyer–Meshkov growth.
- DRACO is a newly developed hydrodynamics code for ICF research.
  - Repeated shock–interface interactions increase the growth rate relative to one shock interaction.
  - Growth of modes can be suppressed by the presence of other modes.
  - Energy removed from the initial modes reappears in other modes.
The shell of an imploding ICF capsule is decelerated by successive reflected shocks

- *LILAC* simulation of a 20-μm CH shell with 3-atm DD irradiated with a 1-ns square pulse
DRACO is a newly developed hydrodynamics code for direct-drive ICF research

- **DRACO** uses the ALE (arbitrary Lagrangian–Eulerian) formulation to solve the hydro equations.

- Physics modules to enable **DRACO** to simulate planar experiments have been added:
  - second-order rezoning
  - interface tracking
  - mixed-material EOS
  - laser-energy deposition
  - radiation transport
Interfaces between materials can be tracked in **DRACO** using methods based on volume fractions

- Youngs’ method* uses the gradient of material volume fraction to draw a straight-line interface in the cell.

- Sod’s problem

\[ \text{Lagrangian calculation} \]

\[ \text{Material 1} \]

\[ \text{Interface} \]

\[ \text{Material 2} \]

Interfaces between materials can be tracked in **DRACO** using methods based on volume fractions.
Interface tracking in DRACO has been tested on a variety of problems

- Classical Rayleigh–Taylor instability

![Graph showing mode-amplitude wavelength over time](image)
A shock-tube simulation is useful to investigate the Richtmyer–Meshkov instability

- Richtmyer–Meshkov instability occurs due to the impulsive acceleration of a perturbed interface by a shock.
- Kelvin–Helmholtz instability leads to roll-up of the spike.
**DRACO** shows good agreement with other codes* for the position of the interface and mix width

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Instability Growth

A succession of shocks reflected between the interface and the fixed wall decelerate the interface.
The effect of successive shock–interface interactions is to increase the mix-width growth rate.
Mode Coupling

A two-mode simulation is used to study mode coupling

\[ \ell = 2 \text{ and } \ell = 7 \text{ at } t = 1.2 \text{ ms} \]

- Small-scale mixing dominates with increasing amplitude of \( \ell = 7 \) for constant \( a_2 \).
- The width of the mix region increases with increasing amplitude of \( \ell = 7 \) for this case.
A modal decomposition of the interface reveals the existence of mode coupling

- The growth of the longer-wavelength mode is decreased when the amplitude of the shorter-wavelength mode is higher.*

Energy from the interacting modes reappears in other modes

- New modes that are sums and differences of the original modes and their harmonics appear in the nonlinear regime.