Multimode Simulations of the Richtmyer–Meshkov Instability Using *DRACO*

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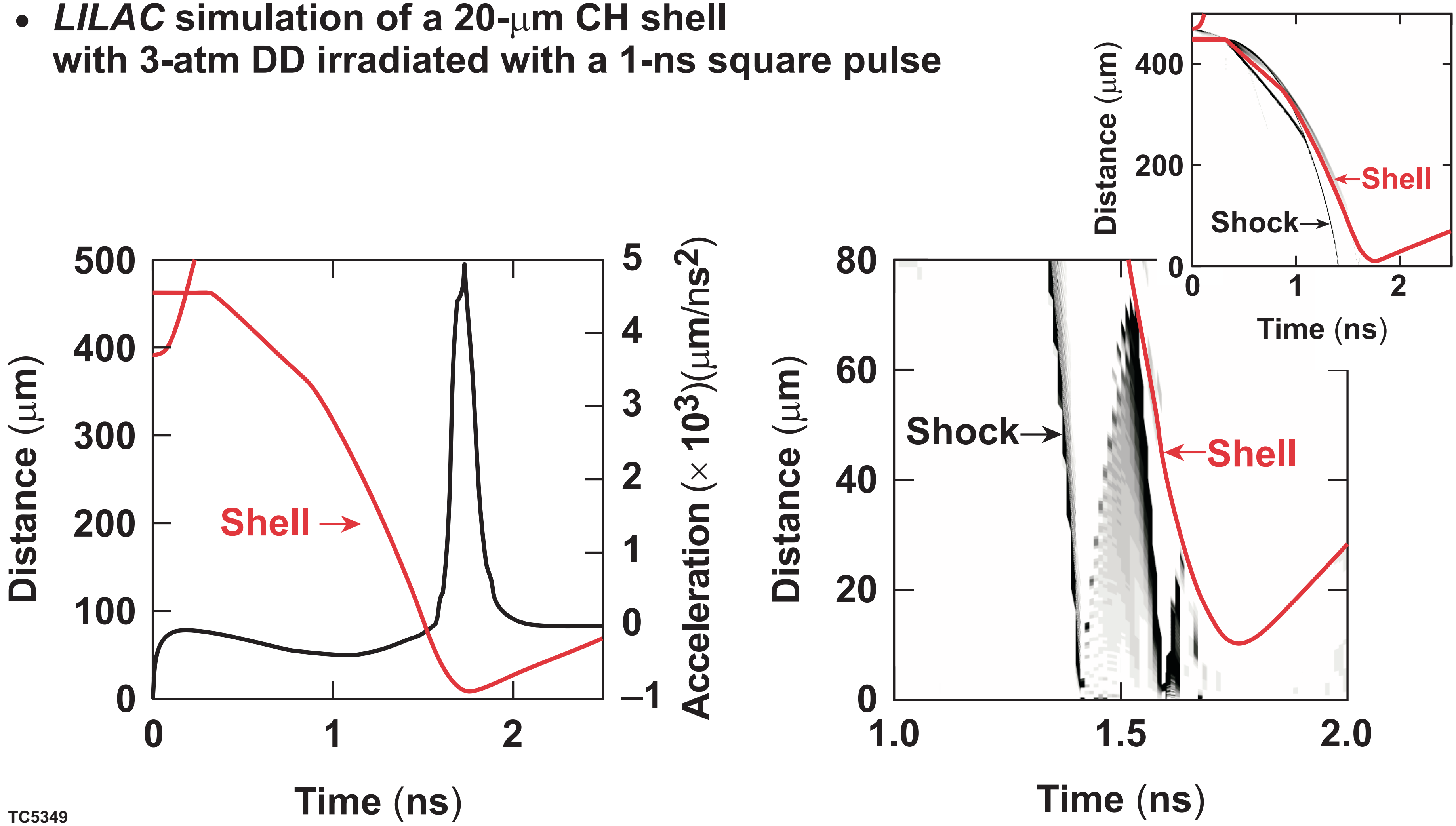
Summary

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.
- *DRACO* has been used to examine the Richtmyer–Meshkov instability in planar geometry.
  - 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



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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

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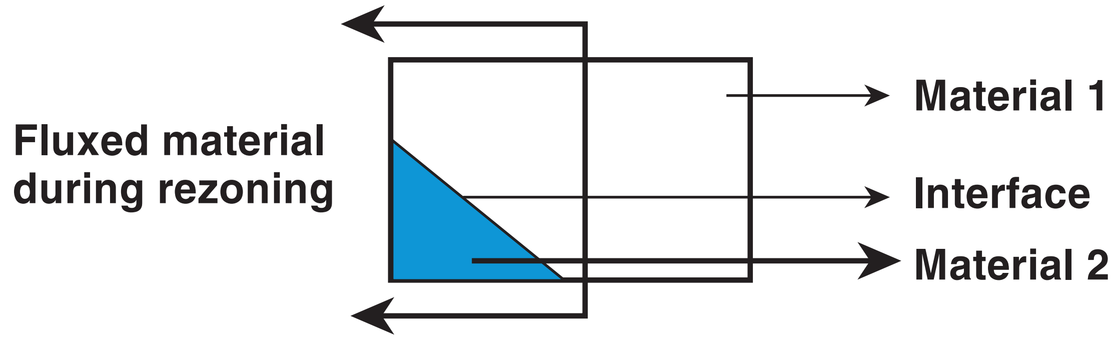
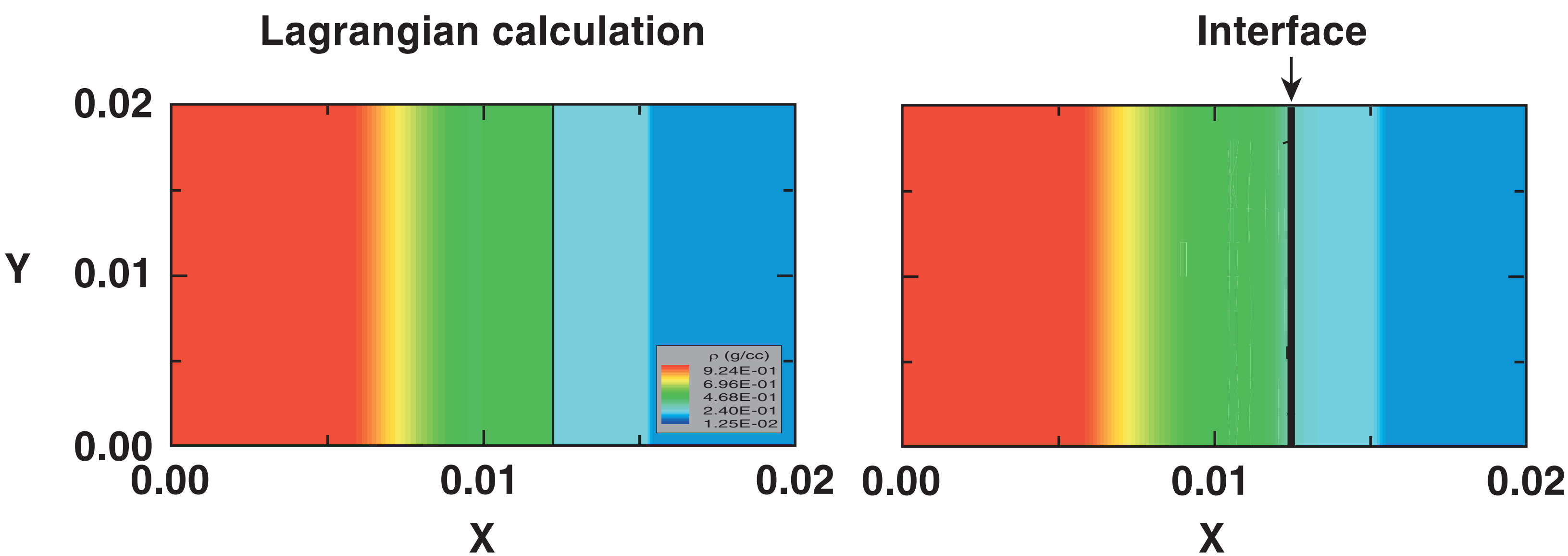
Interfaces between materials can be tracked in *DRACO* using methods based on volume fractions

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



- **Sod's problem**



*D. L. Youngs, Physica D 12, 45 (1984).

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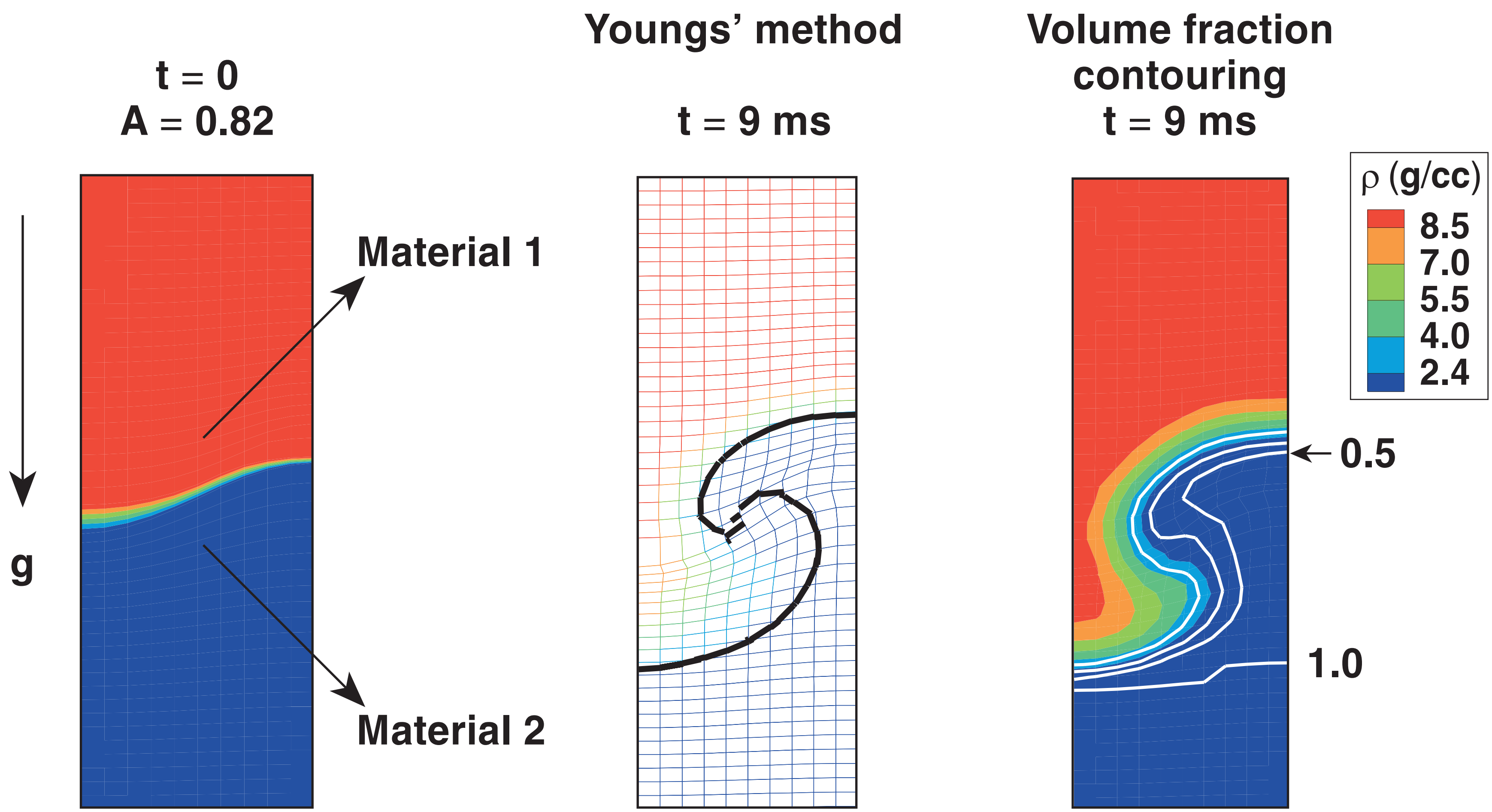
Interfaces between materials can be tracked in *DRACO* using methods based on volume fractions



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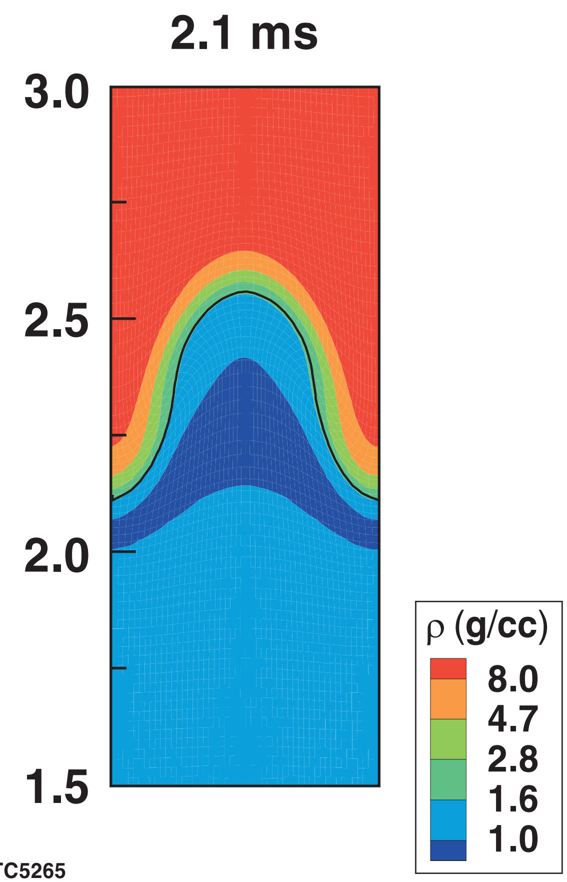
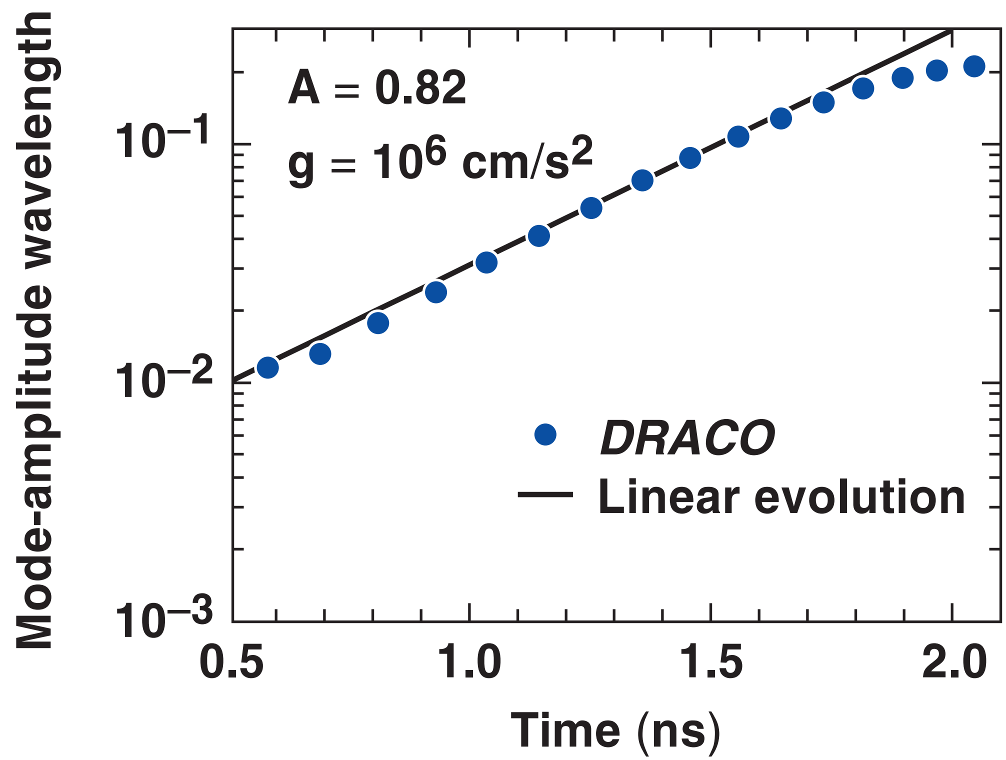
Interface tracking in *DRACO* has been tested on a variety of problems

- Classical Rayleigh–Taylor instability





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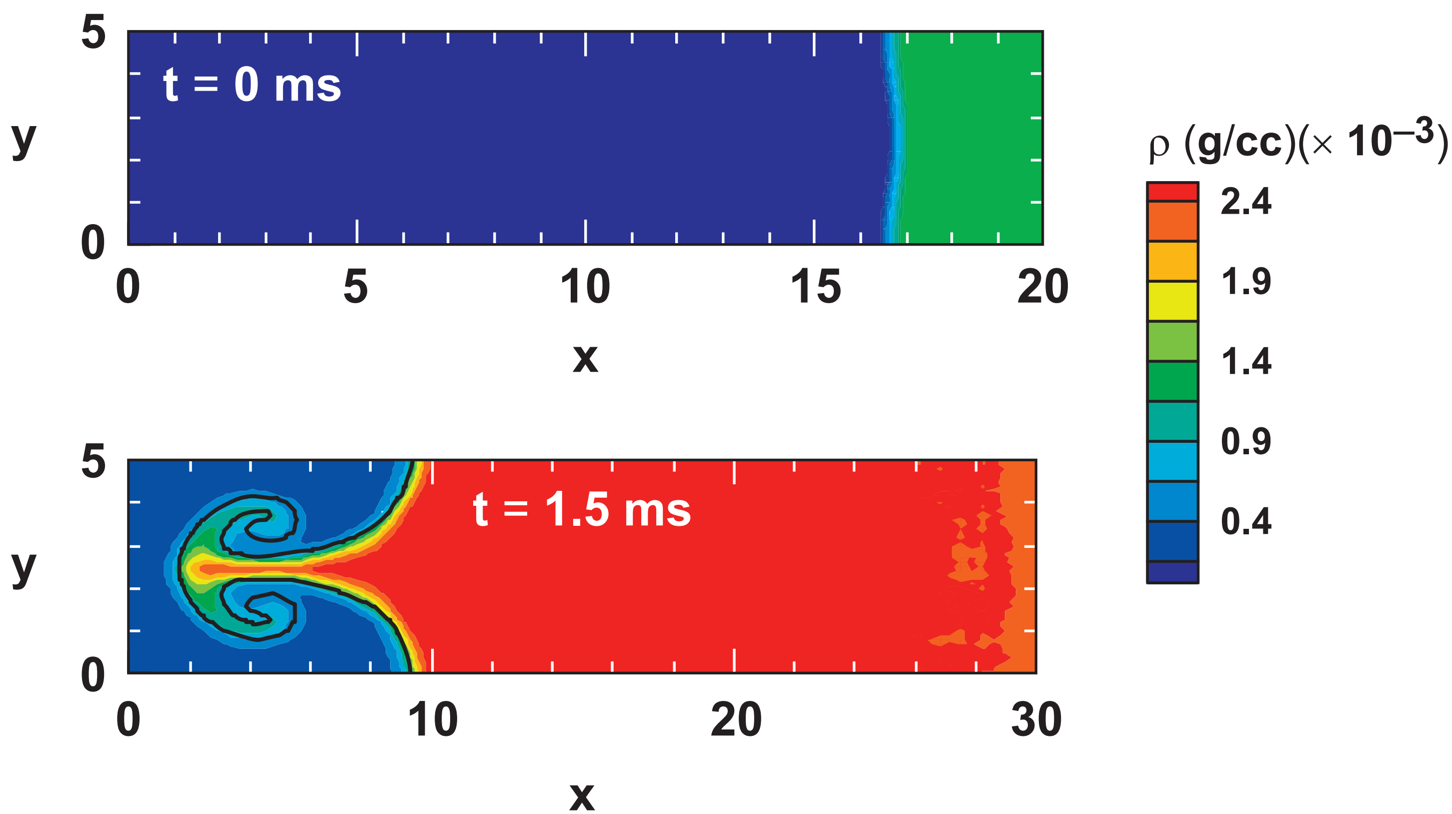
A shock-tube simulation is useful to investigate the Richtmyer–Meshkov instability



- 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.

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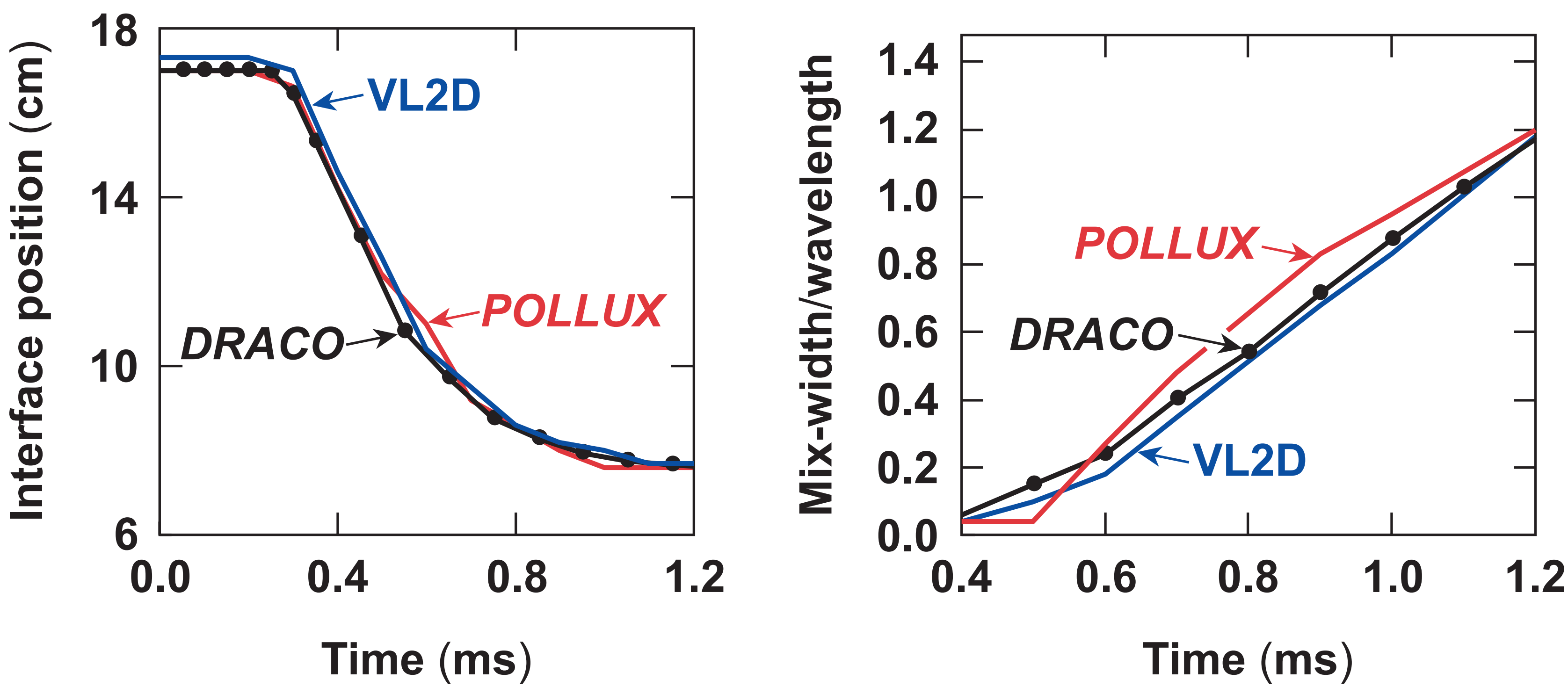
Code Test

DRACO shows good agreement with other codes* for the position of the interface and mix width



**POLLUX*—M. J. de C. Henshaw, Ph.D. thesis, University of HULL (1989).
*VL2D—R. P. J. Town, Ph.D. thesis, Imperial College, London (1990).

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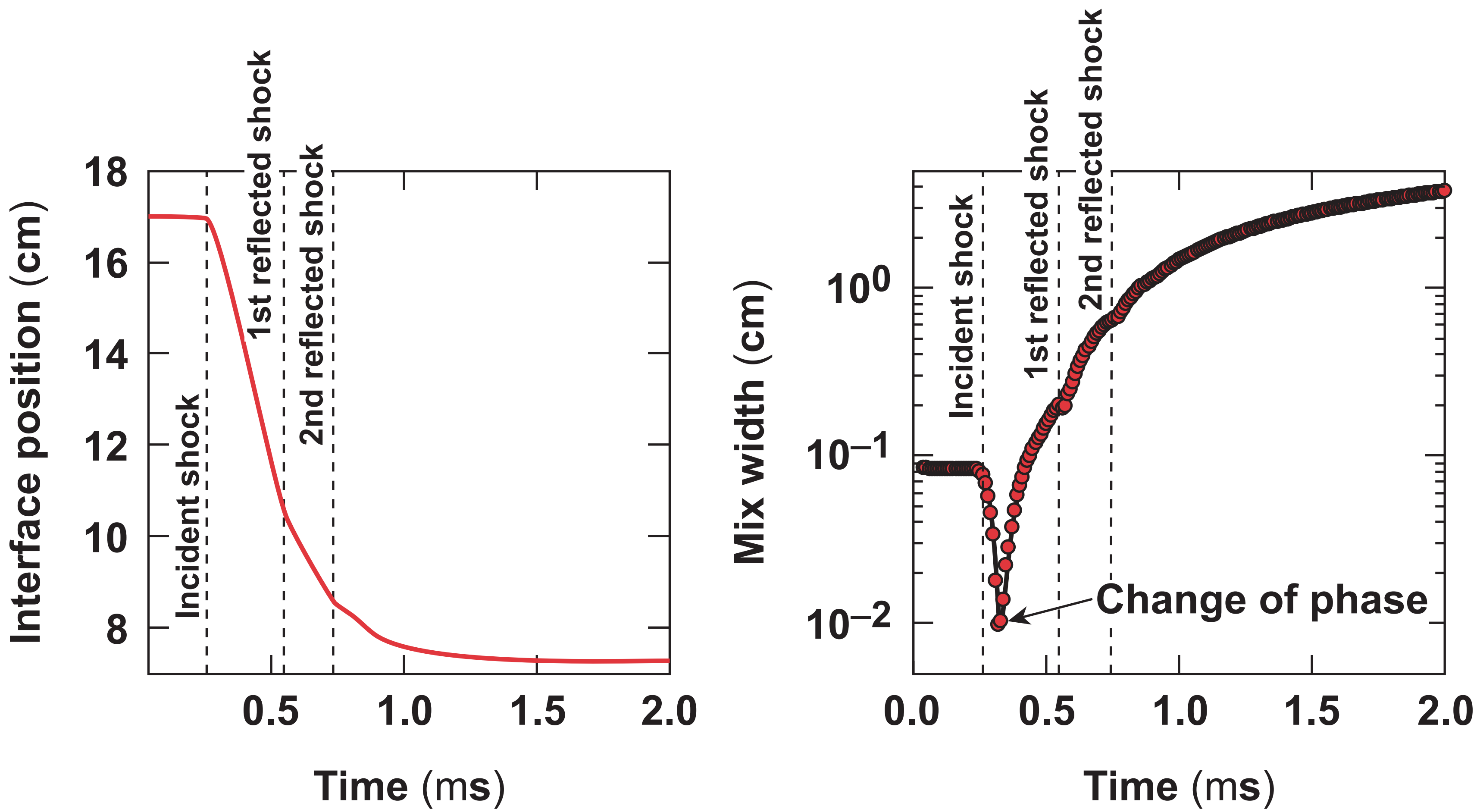
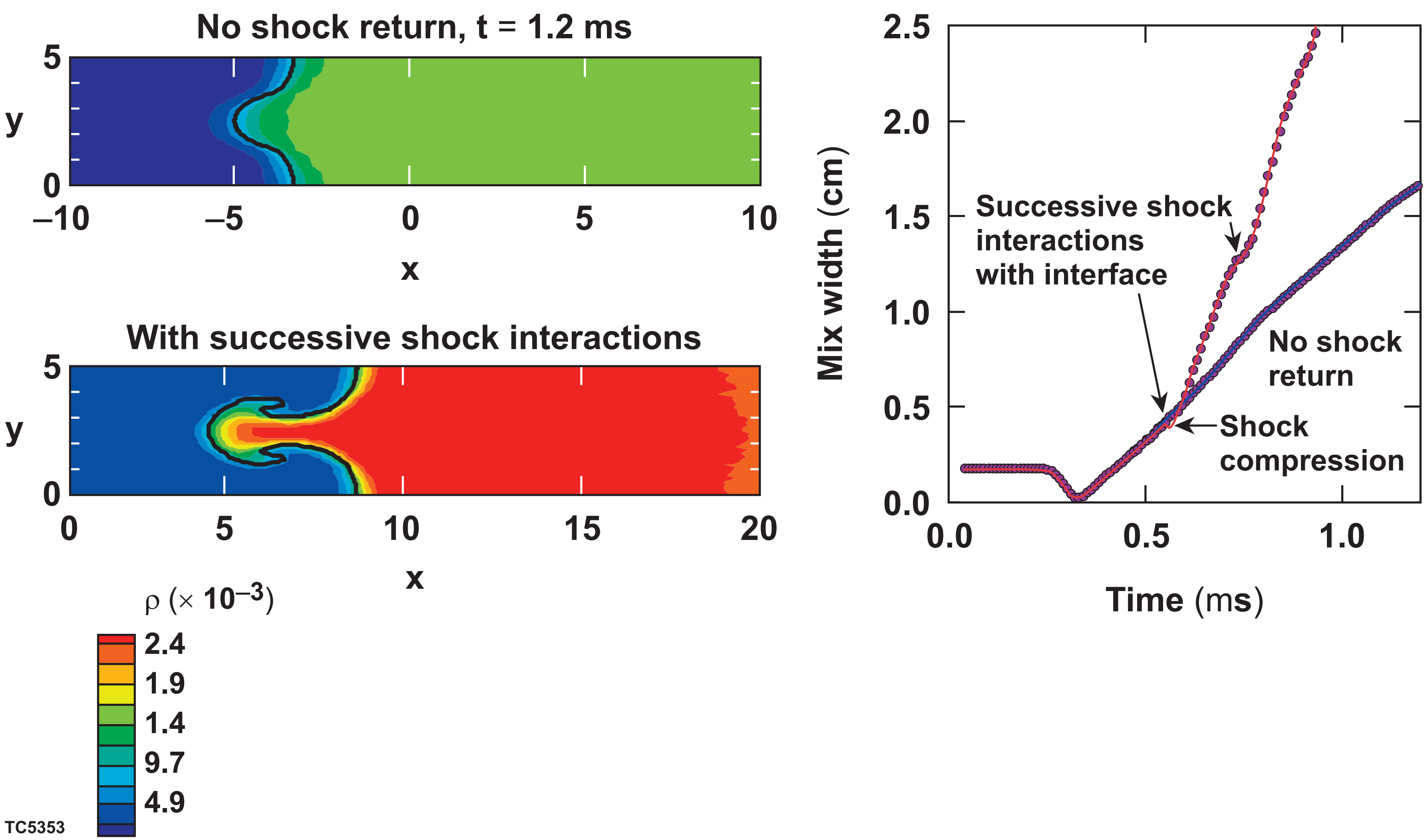
A succession of shocks reflected between the interface and the fixed wall decelerate the interface



The effect of successive shock–interface interactions is to increase the mix-width growth rate



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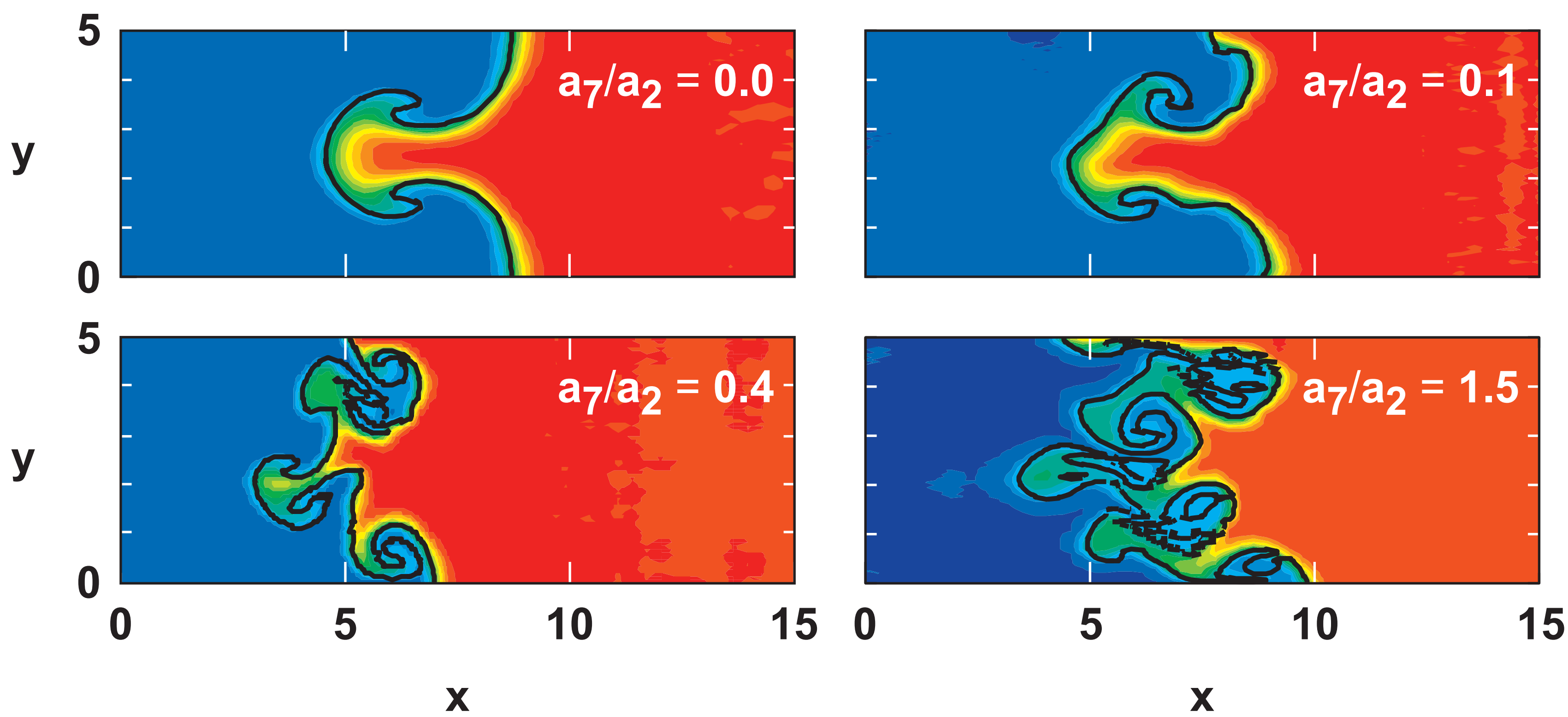
Mode Coupling

A two-mode simulation is used to study mode coupling

$\ell = 2$ and $\ell = 7$ at t = 1.2 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.

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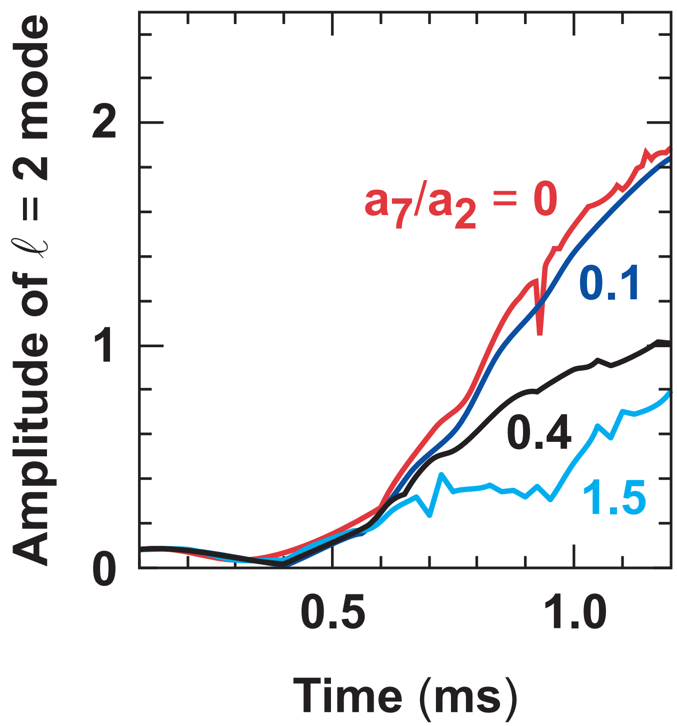
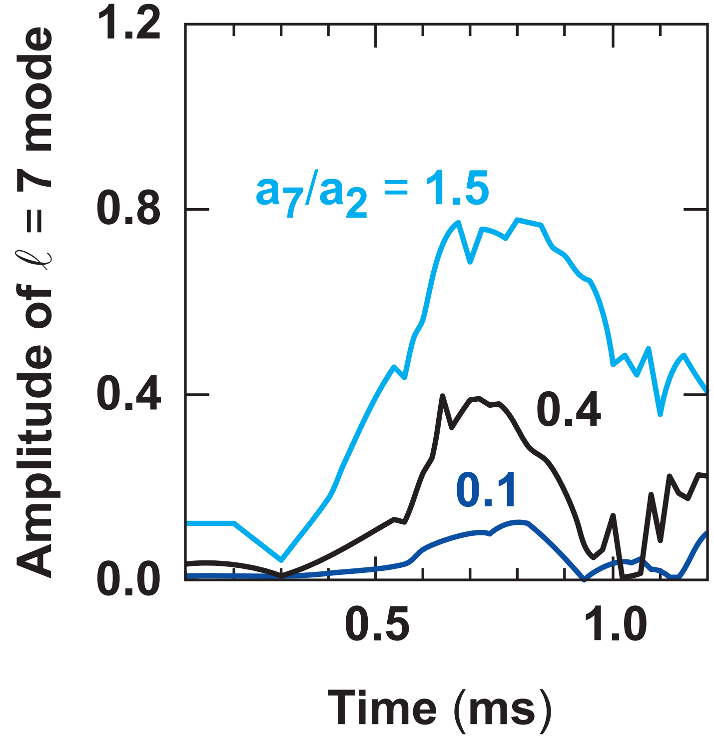
A modal decomposition of the interface reveals the existence of mode coupling





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

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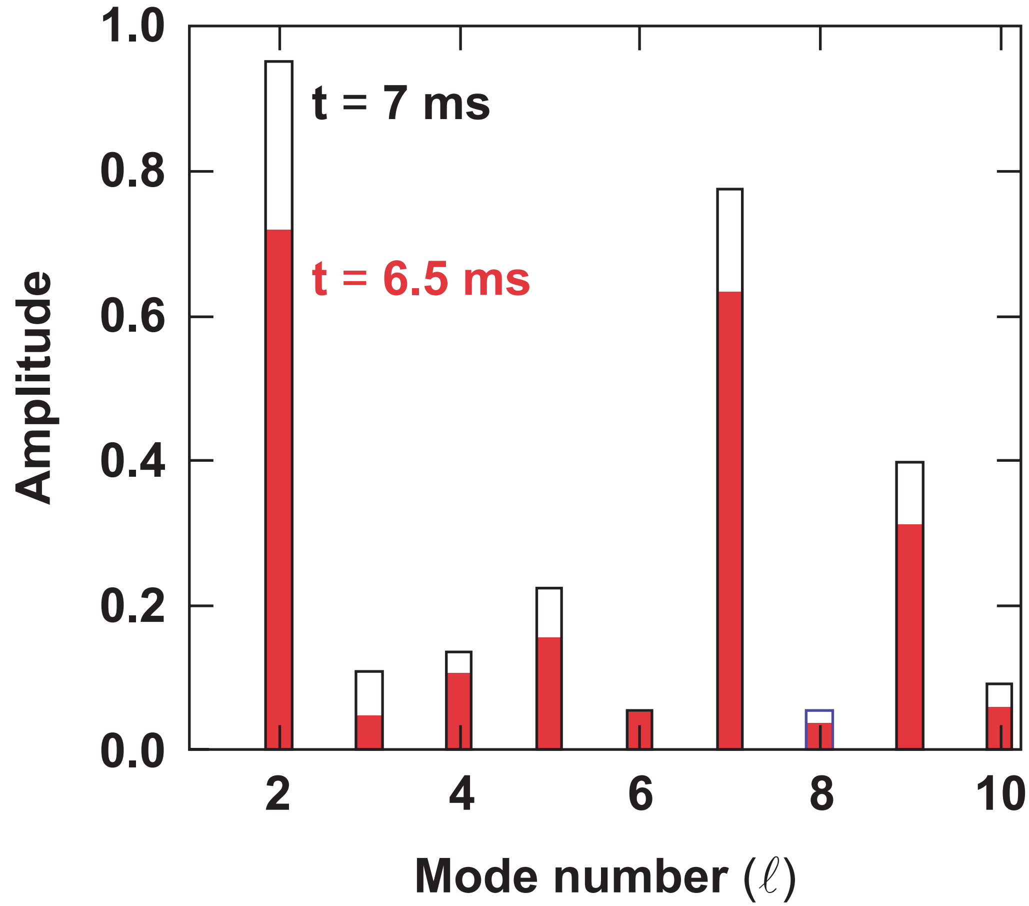
*D. Ofer *et al.*, "Mode Coupling in Nonlinear RT Instability," Phys. Fluids B 4, 3549 (1992).

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.