Investigations of the Richtmyer-Meshkov and Rayleigh-Taylor Instabilities

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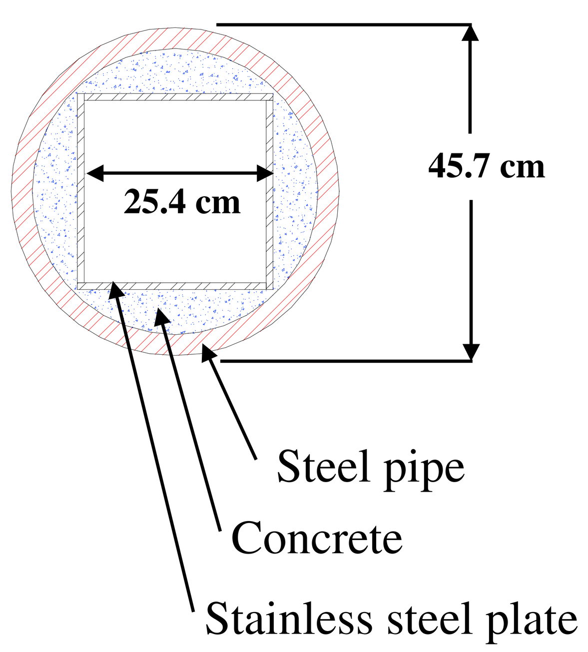
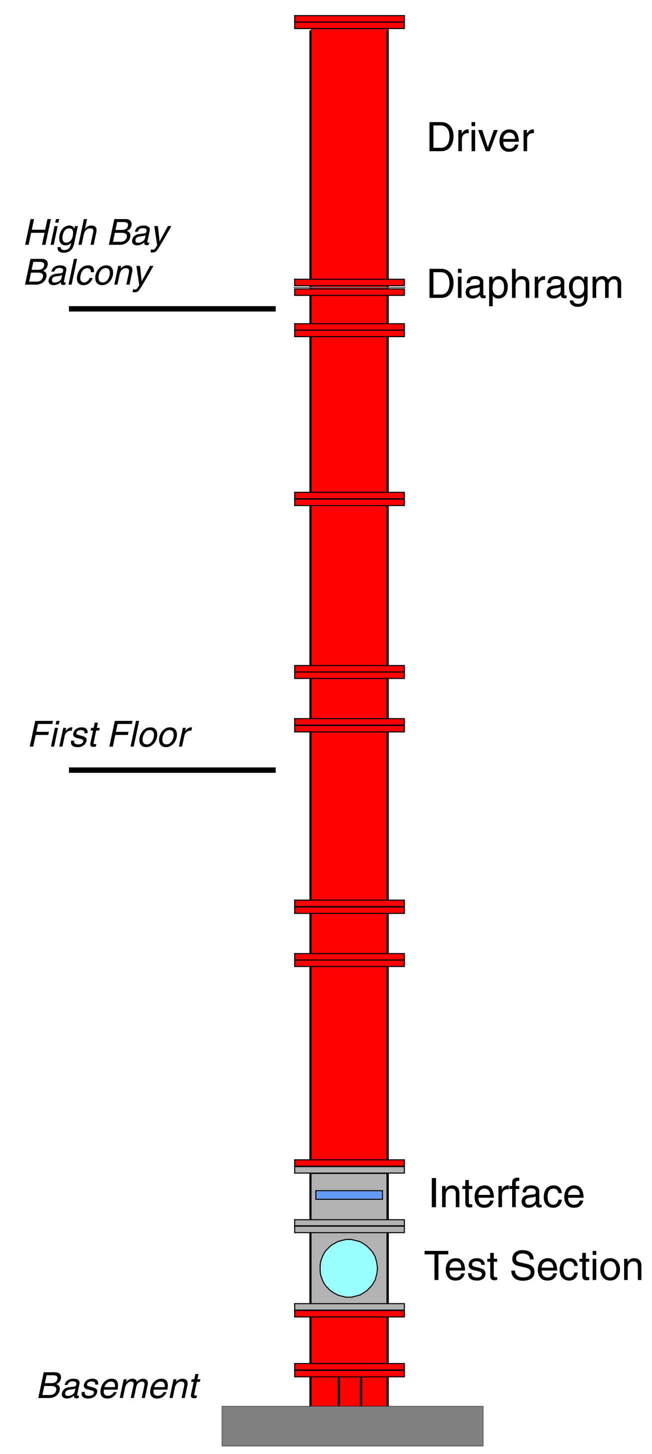
Shock Tube

- Vertical orientation
- Large internal square cross-section (25 cm square)
- Total length = 9.2 m
  Driven length = 6.8 m
- Structural capacity 20 MPa
- Modular construction



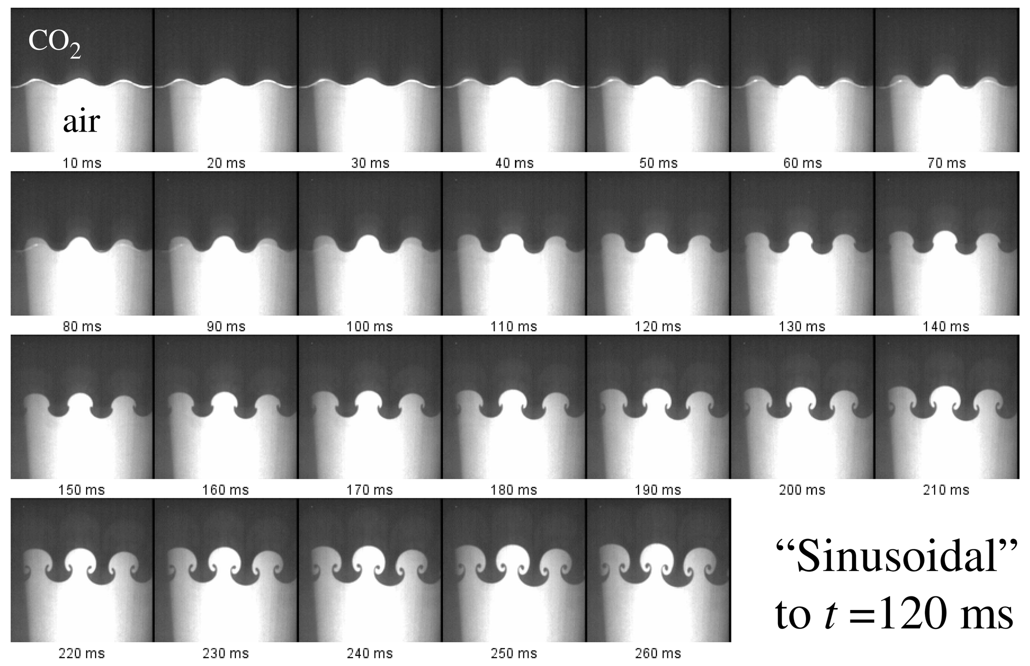


Rayleigh-Taylor Results

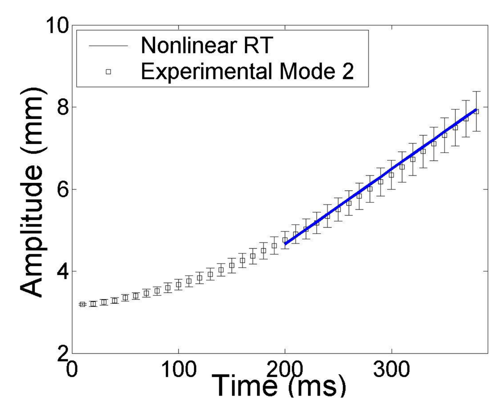
A montage of CO_2-over-air images shows the development of the Rayleigh-Taylor instability using the retractable sine plate technique. The interface between the two gases is well defined up to 260 ms. For studying a predominantly single-mode interface this technique works for this gas pair up to approximately 120 ms. There is excellent agreement with the theoretical bubble velocity for two low Atwood number (*A*) gas pairs.

Asymptotic bubble velocity: $V_{Bubble} = \sqrt{\frac{Ag\lambda}{6\pi}}$

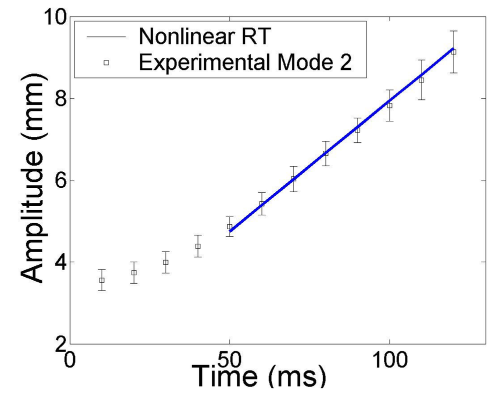
Alon *et al.* Phys. Rev. Let., vol 72, p 2867, 1994
Gardner *et al.* Phys. Fluids, vol 31, p 447, 1998



"Sinusoidal" up to *t* =120 ms



air/N_2 *A*=0.0169

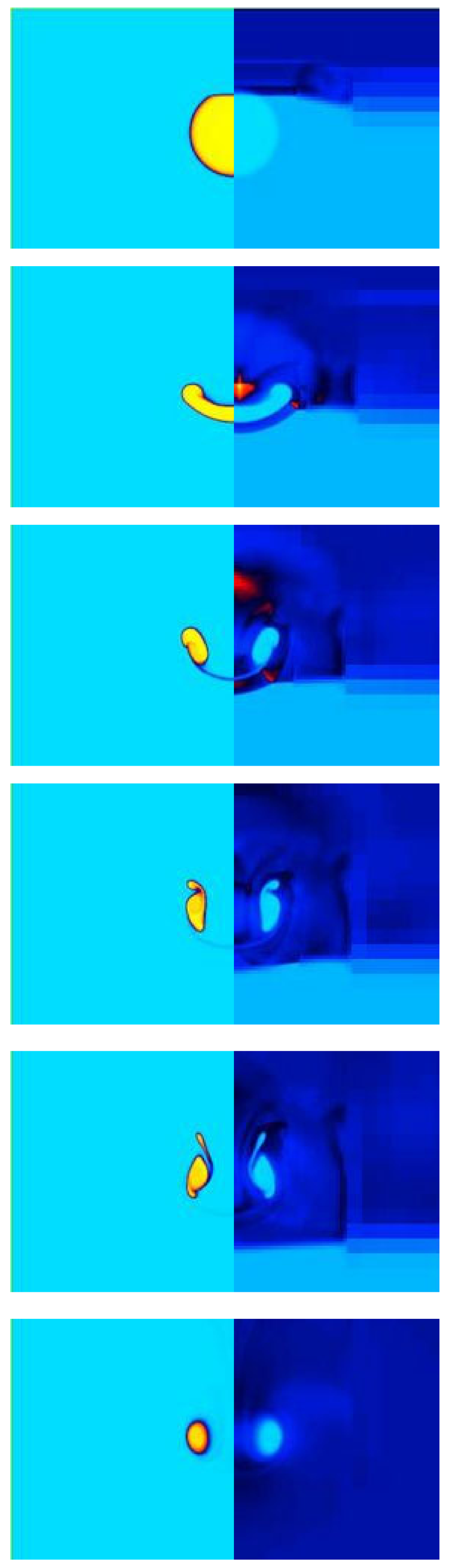


CO_2/air *A*=0.208

Design for Shocked Bubble Experiments

To assist in the determination of optimal experimental settings, a shock-bubble interaction is modeled using the hydrodynamics code *Raptor*. The 25×75-cm domain is divided into 60×180 computational cells with two levels of adaptive mesh refinement at a refinement ratio of four. The upper portion of the domain is filled with shocked gas, and the lower portion with unshocked, quiescent gas. After the problem is initialized, the shock wave propagates downwards and interacts with a bubble of He (modeled as a circle in this 2D case). The bubble is accelerated and deformed under the influence of the shock and breaks off into two spinning fragments. The post-shock bubble development is studied so that electronic trigger times and diagnostics for the experiment may be configured appropriately.

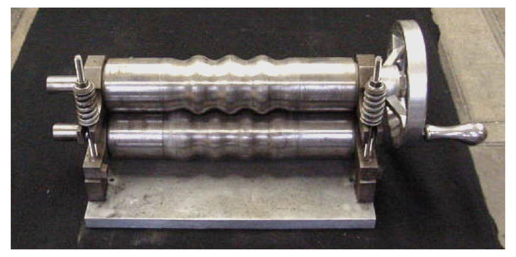
He mass fraction $f(x,y)$	Density $\rho(x,y)$	$t \equiv$ time after initial shock-bubble contact



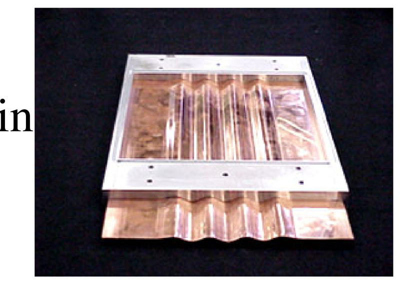
Retractable Plate Experiment

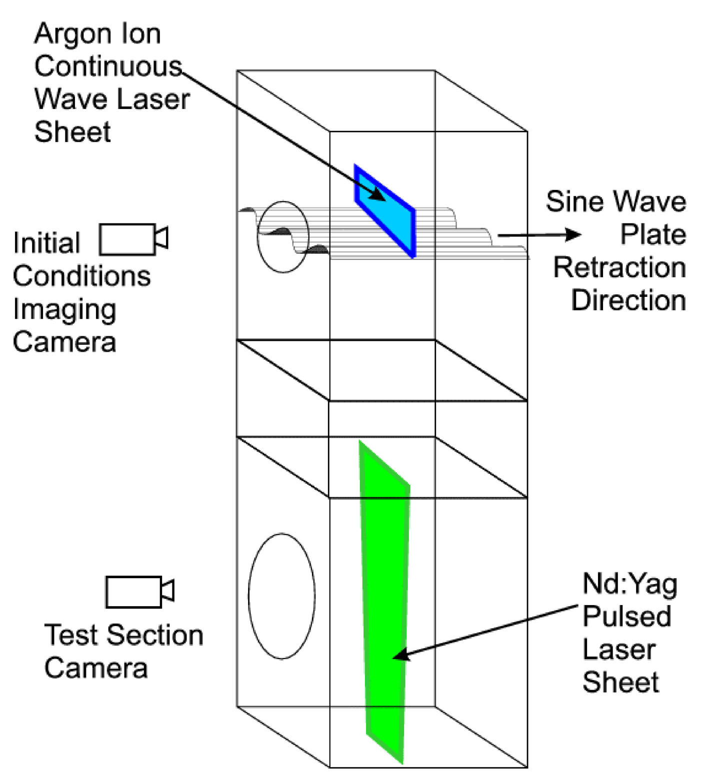
A membraneless interface between two gases has been studied by separating the gases with a sinusoidal copper plate and then retracting the plate prior to shock arrival. The plate is formed from an initially flat sheet fed through a pair of rollers. The plate is inserted in the interface section while held in a support frame with sine wave slot. The plate is retracted, either pneumatically or with a linear electric motor, and the gases come in contact with one another. Using a heavy gas over a light gas configuration, the Rayleigh-Taylor instability develops first, resulting in a growth of the sine wave amplitude, and at a predetermined time, the interface is shocked.

Rollers



Sinusoidal plate in support frame

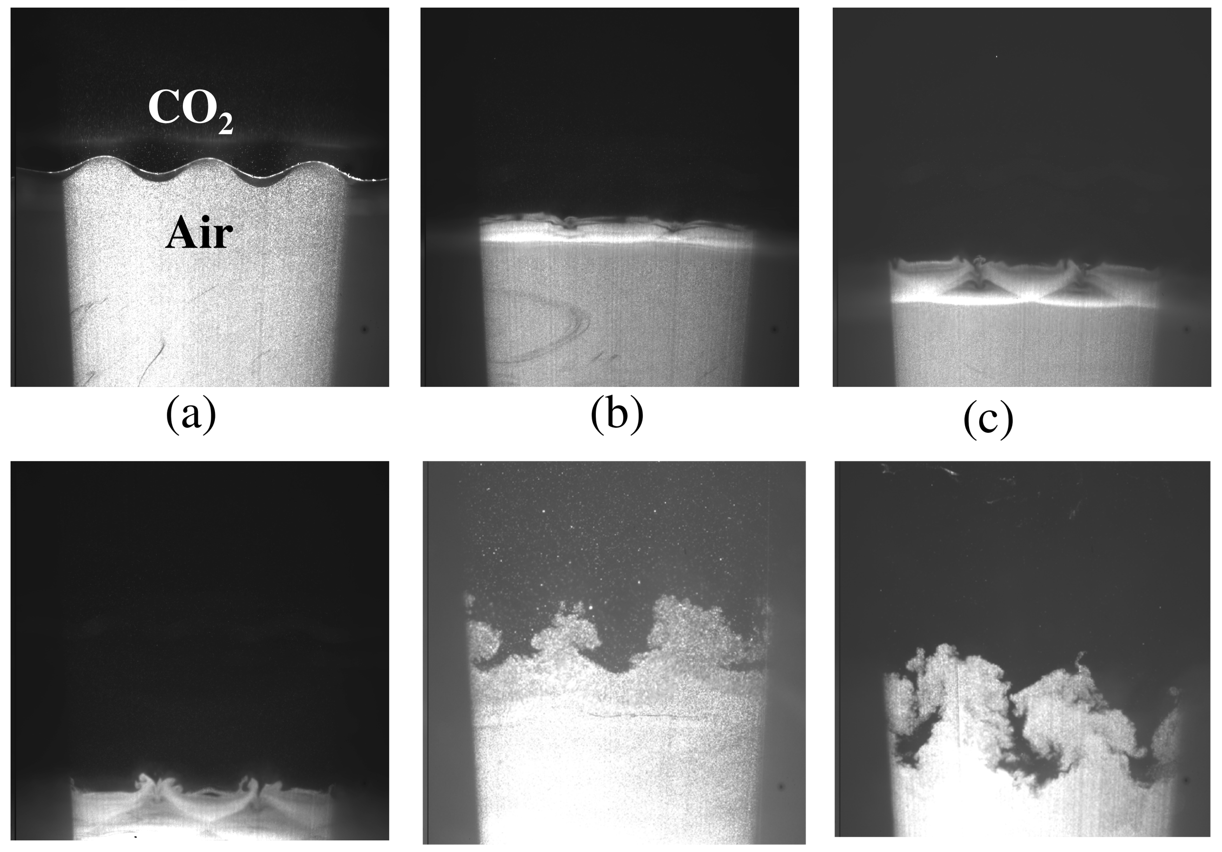




The interface is visualized by seeding one of the gases with smoke particles and then illuminating a 2D slice with a laser sheet. The initial conditions are imaged with a 512×532 pixel array, 100 fps CCD camera, and the shocked image is captured with 1024×1024 pixel array camera. The Nd:Yag laser is pulsed after a predetermined delay from the shock pressure transducer located above the test section.

Richtmyer-Meshkov Results

Interaction of the shock wave with the sinusoidal interface and the development of phase reversal (heavy-over-light configuration). The early-time ($t < 100$ μs) experiments are conducted by retracting the plate out of the back of the test section. The initially planar shock that is transmitted through the interface is distorted due to the geometry of the interface. Fine scale mixing is observed during the phase reversal process, shown below.

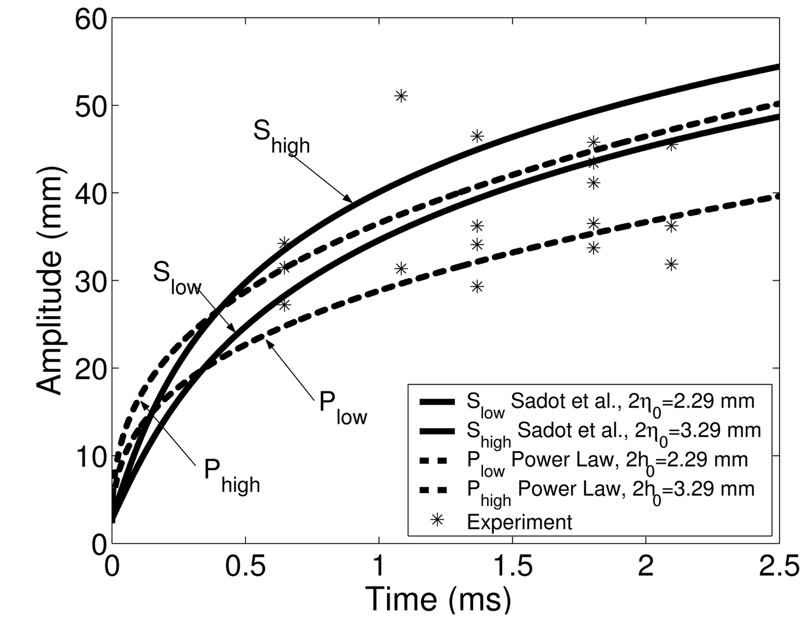


(a) (b) (c) (d) (e) (f)

Ages of shocked interfaces:

(a): Pre-shocked
(b): 5 μs after initial shock acceleration
(c): 36 μs
(d): 39 μs
(e): 646 μs
(f): 1.80 ms

The experimental mixing rates compare favorably with nonlinear and turbulent mixing layer theories. The scatter in the experimental data is due to the difference in interface amplitude from experiment to experiment (2.29-3.29 mm) and three-dimensional effects that are not visible in the plane of the laser sheet.



Sadot *et al.* Phys. Rev. Lett., vol 80, p 1654, 1998
Dimonte *et al.* Phys. Plasmas, vol 7, p 2255, 2000