Excellence in innovative science & technology

Shock Tube Experiments on Richtmyer-Meshkov Instability across a Chevron Profiled Interface

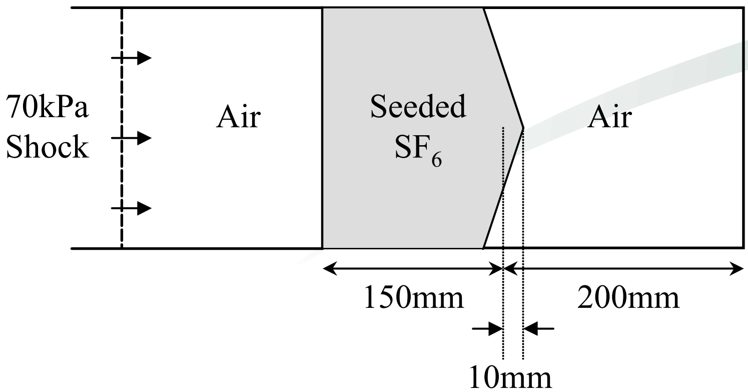
A V Smith, D A Holder, C J Barton, A P Morris
D L Youngs

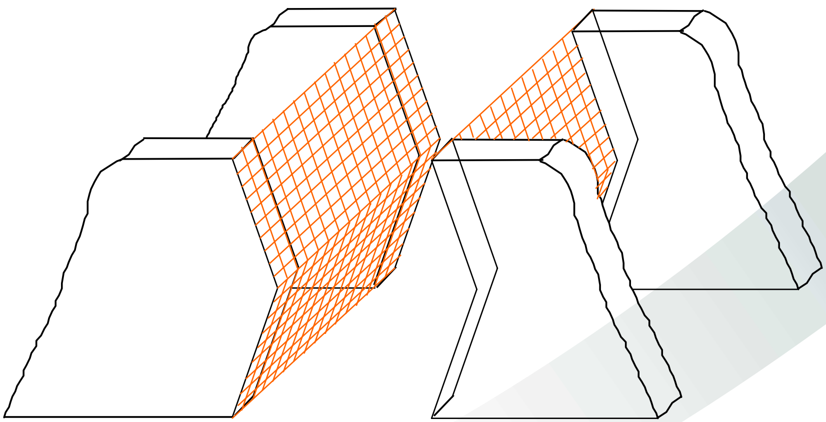
AWE, Aldermaston, Reading, Berkshire, RG7 4PR, UK

Content

- Show experimental mix results from a chevron interface perturbation
  - comparable to numerical test problem #1 and
  - similar to experiments of Meshkov et al (5th IWPCTM)
- Compare these to 3D code results
- Illustrate the potential benefits of Intensified CCD imaging to overcome Multiple Scattering
- Future work
- Video of results

Perturbation





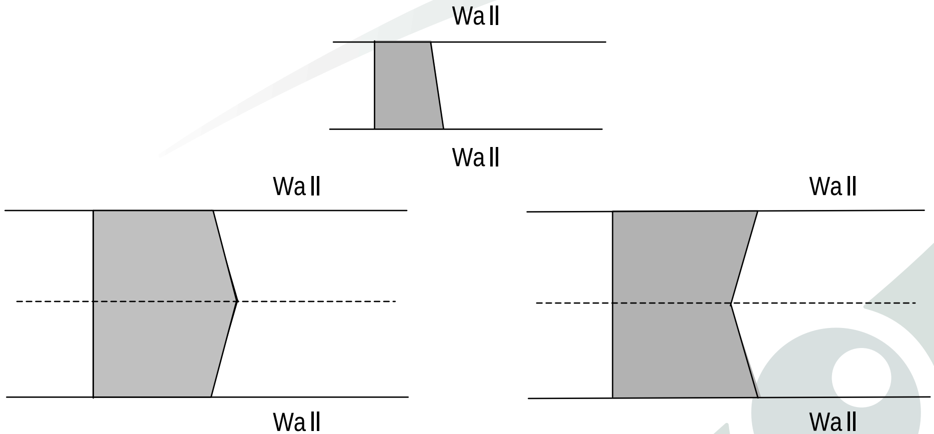
Seeded SF_6 region constrained with microfilm membranes supported on wire meshes.

Meshes on both interfaces are made from horizontal and vertical 25∝m wires with 4mm spacing.

the total flow blockage is 1.25%

Perturbation (cont.)

The chevron was conceived as a progression from the work of Meshkov et al and Test Problem #1.



Presented　　　　Future Work

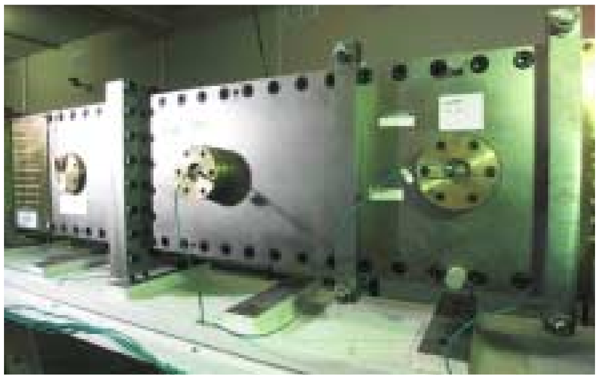
The chevron takes advantage of a larger shock tube to eliminate any possible constraining effect of one wall and also to investigate boundary layer effects.

The two chevron experiments will together complement the previous work

200 x 100 mm Shock Tube

Compression Chamber
Pressurised with Air
to 2 bar

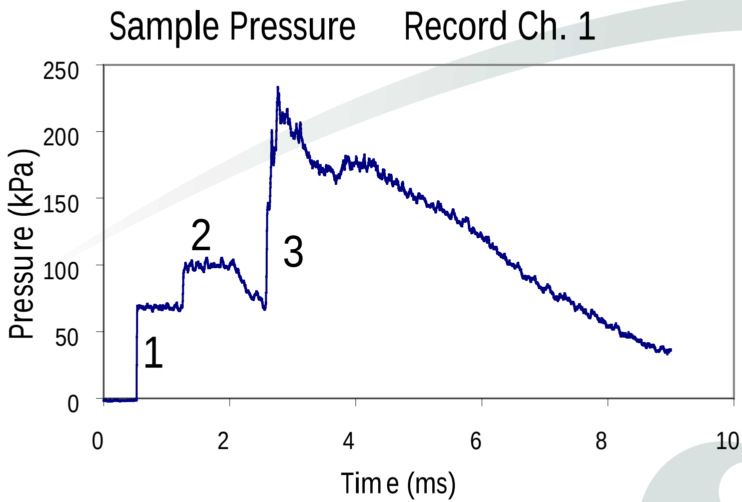
Test Cell
Chevron Interface Profile
SF_6 gives Atwood
Number, A=0.67



Shock of 70kPa
Overpressure and
7ms Duration

Shock Mach Number
1.26

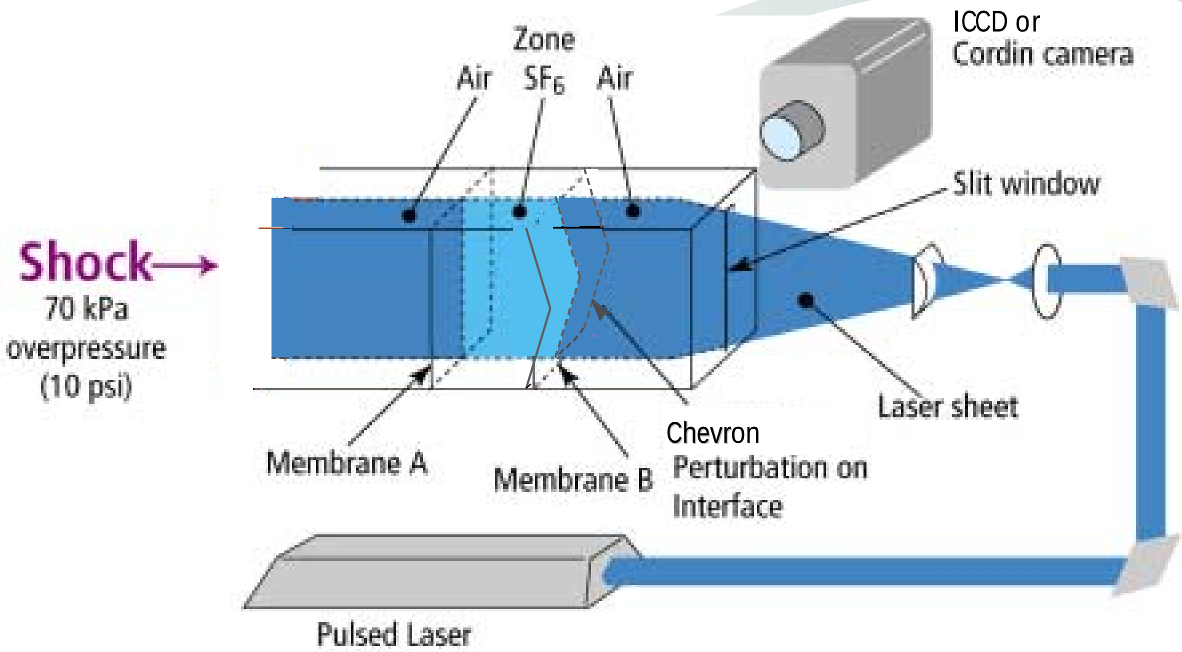
Pressure Profile



Pressure transducers monitor shock passage and record waveforms. This is a typical waveform from the pressure gauge nearest the test cell.

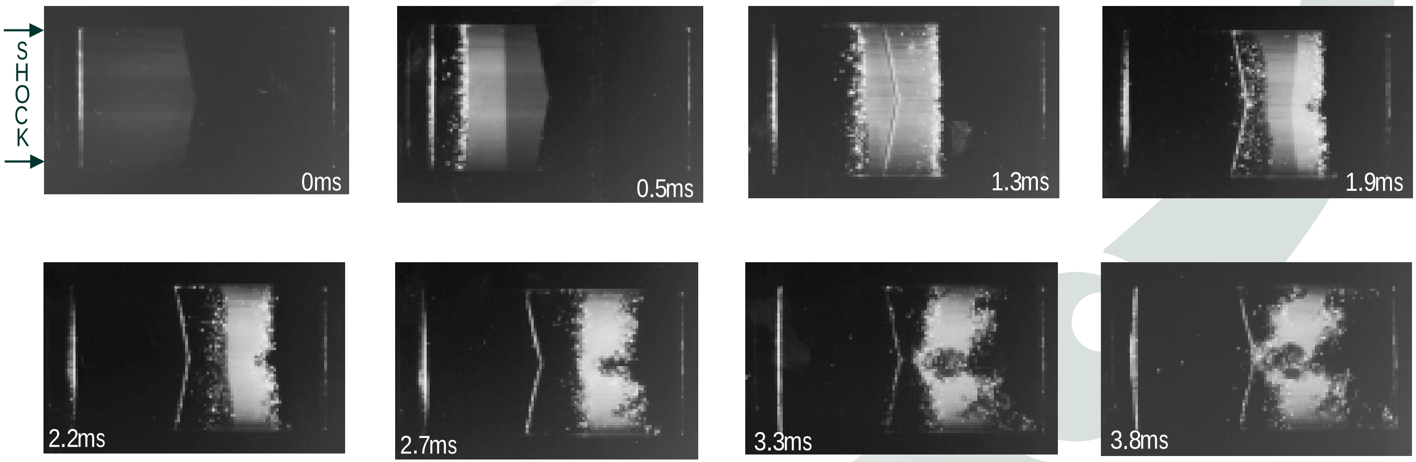
1. Incident shock
2. First shock reflection from dense gas region
3. First shock reflection from end wall

Laser Sheet Arrangement

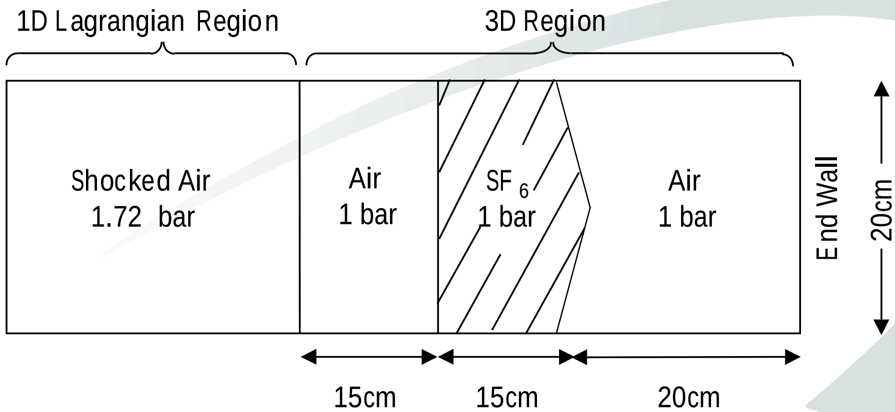


Chevron Experiment

Sequence of selected images from a single experiment



TURMOIL 3D Calculations



Zoning used in 3D region : 400 x 320 x 160

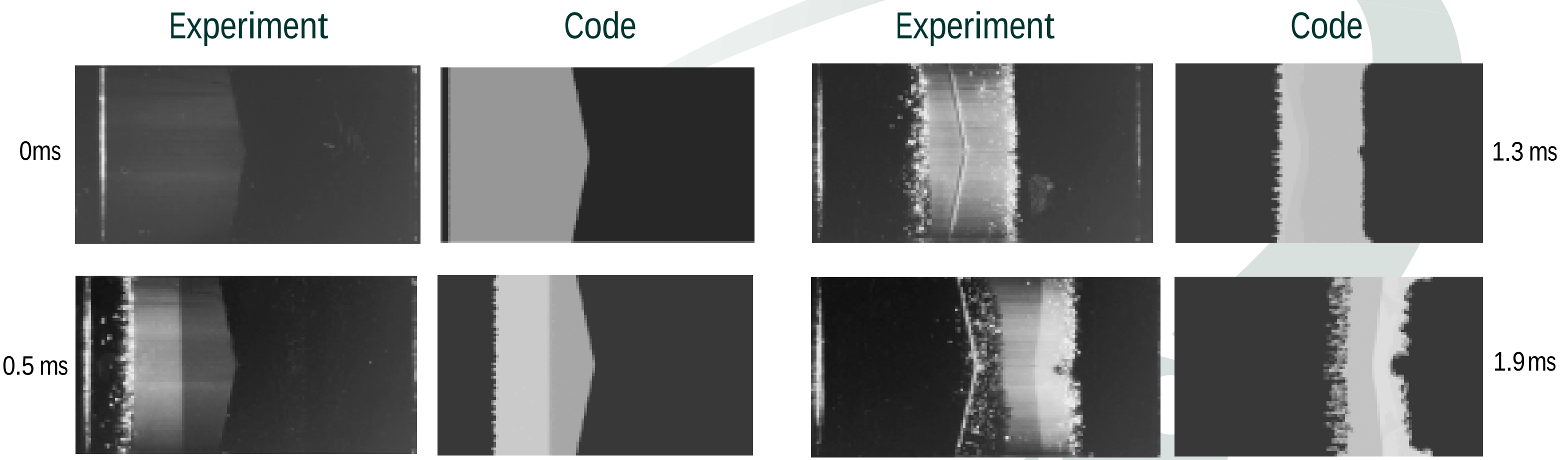
Semi-Lagrangian calculation : x-direction mesh moves with the mean fluid velocity.

Random initial perturbation at air/SF6 interfaces:

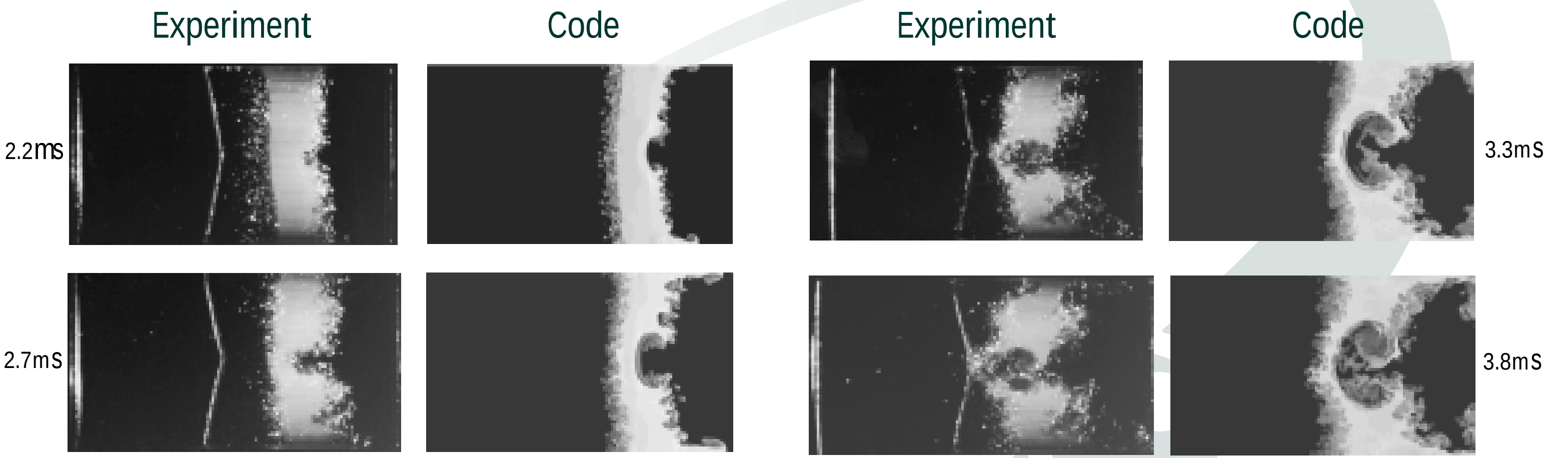
Wavelengths = 0.5 to 5cm

R.M.S. amplitude = 0.01cm

Experiment and Code Comparison (0 - 1.9ms)



Experiment and Code Comparison (2.2 - 3.8ms)



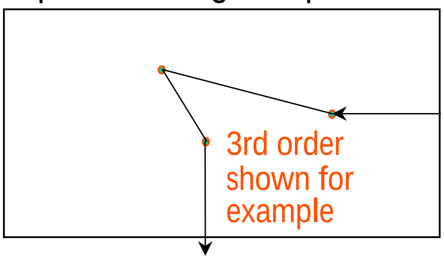
AWE Excellence in innovative science & technology

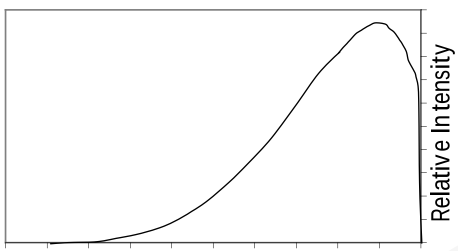
Multiple Scattering

A Monte Carlo multiple scattering simulation has been devised to successfully 'add' multiple scattering to the mix code results.

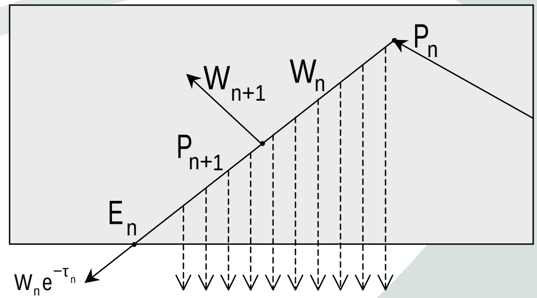
Ref: Giddings et.al. 7th IWPC TM
Holder et.al. 23 rd ISSW

Multiple scattering in experiment

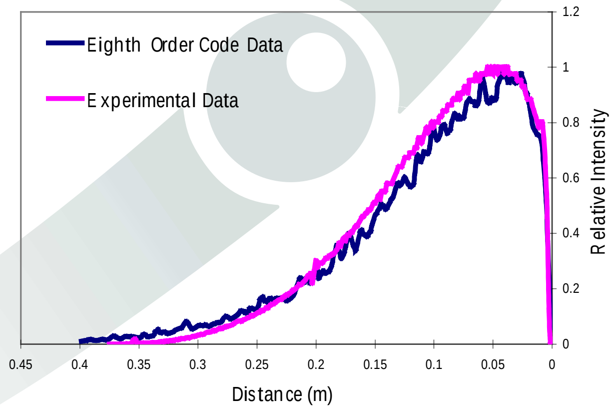




Monte Carlo code simulation

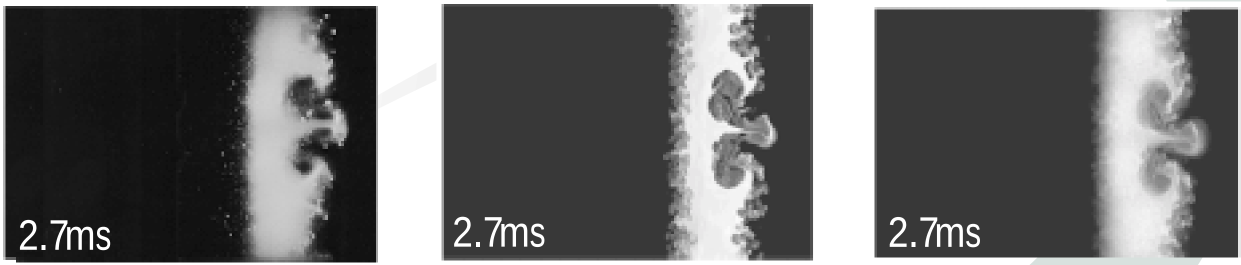


Contributions to scattered image



Multiple Scattering Example

Experiment | Code | Code + Scattering



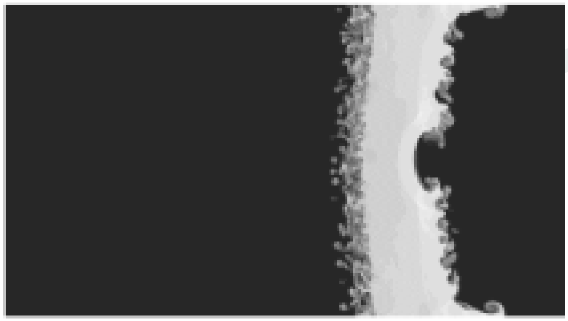
These are images from a single time (2.7ms) from a double bump experiment presented to ISSW 23.

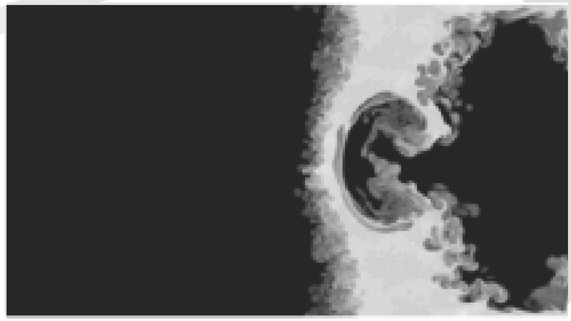
These are an experimental image, a plane section through a mix calculation and the same calculation with the Monte Carlo simulation applied.

The Monte Carlo scattering code greatly improves qualitative comparison between experiment and code results.

Wall Effects

Code results at 2.2 and 3.3 ms





Spikes of dense gas are seen to advance along the top and bottom.

Are these due to the Chevron pert urbation, boundary layer interactions, or a combination of both ?

The bubble of air penetrating into the dense gas is not axi-symmetric. Would the presence of a wall, as in numerical Test Problem #1 prevent this occurring?

Conclusions

- Chevron perturbation appears to produce feed-through in the experiments, but not in the code results.
- Acceptable agreement between experiment and code has not yet been achieved. The experiment will have to be repeated.
- Inverse chevron experiment to
  - further investigate boundary layer effects
  - investigate asymmetric effects
- Further use of ICCD imaging and fluorescent seeding
  - allows a reduction in multiple scattering
  - promising for future, allowing quantitative analysis
- Chevron experiments are useful to validate test problem calculations in addition to the work of Meshkov et al..

See next page for **Video of Results**

Code Data

Move cursor over image and click to play

Experimental Data

Move cursor over image and click to play