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Richtmyer-Meshkov instability at a gas interface accelerated by a Mach 10 shock wave

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Results are presented from experiments performed at the LANSCE Proton Radiography Facility studying the interaction of a planar shock wave of strength $M = 10$ with a gaseous interface between xenon and helium. The Xe/He interface has an Atwood number of 0.94. Because of a large initial density difference between the gases, and the high impact strength of shock wave, these experiments are applicable to Inertial Confinement Fusion (ICF) environments where small capsules containing deuterium-tritium (DT) fuel are compressed by laser-generated shock waves to initiate a very rapid thermonuclear burn. Due to manufacturing limitations, there are small perturbations on the interface between an ablator and the solid DT fuel, and on the interface between solid DT fuel and gaseous DT fuel for ICF. In our experiments, we use an aluminized mylar film of thickness 25 microns and an aluminium mesh (different sizes, e.g. 10x10 wires per inch, 0.635 mm wire, with approximately 2mm gap) to separate xenon from helium. The mesh serves to seed a prescribed initial perturbation between the gases (Andrews et al. 2006). Figure 1 shows a photograph of the assembled test section before the experiments.

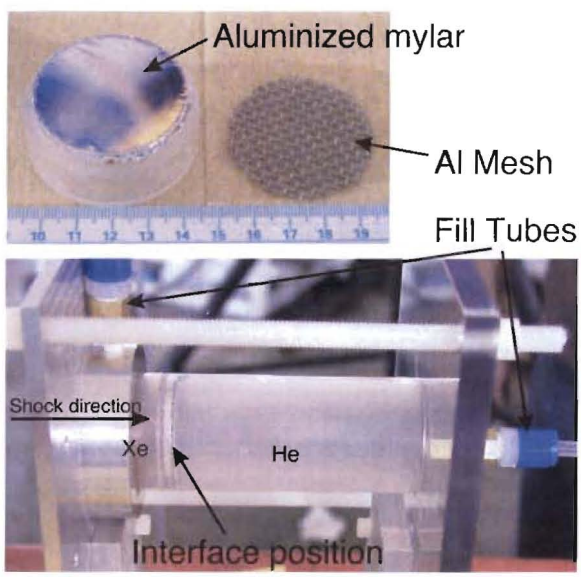

Figure 1. Photograph of the experimental setup. Also shown in the figure is aluminium mesh and the aluminized mylar membrane glued to the upstream chamber of the test section.

Prior to filling the test section, we evacuate both chambers to the pRad vacuum pressure (3 torr), and ensure the purity of gases in both chambers. The upstream chamber of the test section is filled with xenon (approximately 610 torr), and the downstream chamber with helium (approximately 600 torr). A small pressure difference (10 torr) between the gases is maintained to ensure that the mylar film did not break during the filling process. We use high explosive (HE) to drive a projectile, which hits the KAPTON wall (approximately 6 microns thick) on the xenon side and generates a planar shock wave that traverses though the xenon toward the mylar membrane (see Fig.2). When the shock wave crosses the density interface it drives the formation of Richtmyer-Meshkov instabilities. The subsequent evolving flow field is imaged with proton radiography to measure the instability growth rate and turbulent mixing. The facility is capable of acquiring twenty one high resolution images per shot, that allows us to study the growth of the instability. This is an on-going research program, and so we shall describe the experimental setup in detail and the preliminary results obtained from our last three shots.

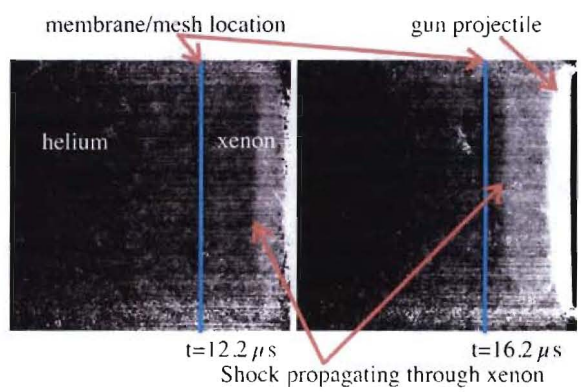

Figure 2. Proton radiography image showing shock wave propagating through the xenon right before impacting the membrane/mesh interface. The gun projectile is also visible in the second image.

References

Andrews M, Gore R, Hill L, Frank M, Prestridge KP (2006) Progress with High Ma Richtmyer-Meshkov Experiments. APS-DFD Meeting, Tampa Bay.

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