Tue4.4 Tomkins et al.

Visualizing the onset and growth of secondary instabilities in Richtmyer–Meshkov-unstable flows

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We report high-resolution concentration measurements of secondary instabilities developing along shock-accelerated material interfaces at intermediate and late times (~300-700 μs after shock passage) for the case of a shock interacting with a cylinder of heavy gas in air. The cylinder is formed by steadily flowing the heavy gas (SF_6) through a 5-mm circular nozzle under the influence of gravity; the cylinder is then impacted with a planar, Mach-1.2 shock. A recently implemented quantitative planar laser-induced fluorescence (PLIF) diagnostic is used to capture the concentration field of the heavy gas at several instances after shock passage, and the technique reveals fine details of the structure. Of particular interest in the present study is the development of secondary instabilities. Evident in the visualizations are two types of secondary instabilities, apparently distinct, with different characteristic length scales: one appears along the outer edge of the structure, and the other is manifest within the vortex cores (see Figure 1).

The nature of the mechanisms driving the secondary instabilities is also investigated. Particle image velocimetry (PIV) measurements, which provide 2-D velocity field data in a plane with high resolution (187um vector spacing), are performed at late time. These data are analyzed to identify the regions of the flow that may be expected to have the highest receptivity to the secondary instability mechanisms in question.

Figure 1: PLIF measurement of a single shock-accelerated gas cylinder at 680 μs after shock passage. Flow direction is top to bottom.