Bursting of a Peach-Shaped Wave: High Speed Schlieren Visualization of Detonation Diffraction in Gases

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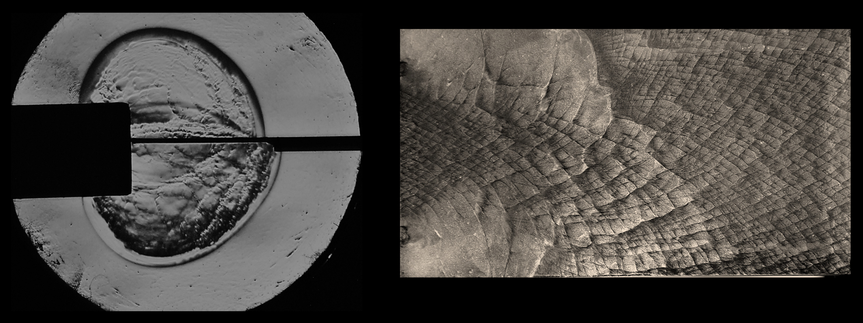

Figure 1. Smoked foil technique for the visualization of the cellular pattern evolution in gaseous detonation diffraction.

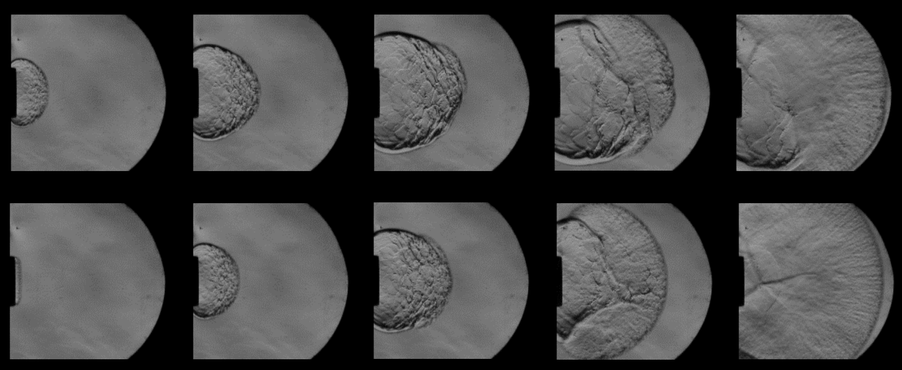

Figure 2. Multi-frame Schileren visualization at 100k fps of the detonation diffraction process. The mixture is stoichiometric acetylene-oxygen at an initial pressure of 6.3 kPa (top) and 7.2 kPa (bottom).

Gaseous detonations are self-sustained, combustion-driven waves traveling at supersonic velocities on the order of 2 km/s. These waves are intrinsically unstable with a complex frontal structure embedded with small-scale instabilities and their propagation relies on the interactions of transverse waves.[1] When a planar detonation emerges from a confined tube into an open area, expansion waves from the periphery will influence the propagation of the diverging detonation, creating a peach-shaped wave form. Below a critical tube diameter, the emerging planar detonation will fail with a continuous decoupling between the leading shock front and the chemical reaction zone. For successful transmission, a sufficient level of cellular instabilities has to be maintained to sustain the detonation propagation in the open area. Re-initiation is found to originate from localized regions in the peach-shaped wave surface, i.e., the appearance of an explosion bubble that subsequently sweeps around the complete wave front. These flow features of detonation diffraction are observed using the Schlieren photography[2] with a high-voltage arc in argon gas for single-frame, high-resolution imaging illumination and a high-speed Photron FASTCAM SA1.1 camera with the Oriel Apex Hg(Xe) arc lamp light source for multi-frame visualization. The cellular frontal pattern evolution during the detonation diffraction is tracked by placing a thin metal foil coated with a uniform soot layer, as illustrated in Figure 1. A sequence of video frames showing the evolution of the detonation bubble is also shown in Figure 2.

[1] J.H.S. Lee (2008) *The Detonation Phenomenon*. Cambridge University Press, Cambridge.

[2] G.S. Settles (2006) *Schlieren and Shadowgraph Techniques: Visualizing Phenomena in Transparent Media*. Springer, Berlin.

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