“Early Spray Development at High Pressure: Hole, Ligament, and Bridge Formations”
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Tuesday, September 22nd, 2015, 4:00 pm | B11 Kimball Hall
Refreshments at 3:30, Upson Hall Lounge

Abstract
Three-dimensional temporal instabilities, leading to spray formation, of a round liquid jet segment with co-axial gas flow at high pressure are studied by Navier-Stokes and level-set computations. Post-processing demonstrates a strong relation between surface wave dynamics and vorticity dynamics; in fact, a duality of the character is found. Liquid-surface shape shows the development of smaller structures on the conical wave crests, i.e., lobes, holes, bridges, and ligaments. The gas-to-liquid density ratio, liquid Reynolds number (Re), and liquid Weber number range between 0.05 to 0.9, 320 to 5000, and 2000 to 230,000, respectively. At higher Re, lobes are longer and curve more at the crest edge with a regular formation of holes. The crest rims eventually tear, transforming the crest rims to ligaments. At higher gas densities throughout the Re range, the lobes are regular but shorter. The holes merge before the rims break to form ligaments. Consequently, liquid formations with both rim bridges and middle bridges are more common in this domain. In cases where both gas density and Re are lower, the well-ordered lobes are replaced by a more irregular corrugation with more wrinkles along the conical wave crest edge. Ligaments stretch from the lobes before holes form. The more viscous crests are thicker here explaining a delay in hole formation; still, the ligament extension is driven by pressure gradient rather than shear at the gas-liquid interface. In all cases, hole formation is correlated with hairpin and helical vortices; the perforations correlate with resulting fluid motion. Qualitative agreements with experiments are very good.

Biographical sketch
Research Interests and Accomplishments: spray combustion, aerospace propulsion, combustion instability, automotive combustion, fire research, noise suppression, nonlinear oscillations in an unstable combustor; nonlinear fluid dynamics for Helmholtz resonators; admittance for oscillatory, 3D nozzle flows; condensed-phase behavior in flame spread above liquid and solid fuels; ignition of combustible gas by a hot projectile; turbulent flame and propagation in reciprocating and rotary internal combustion engines; droplet vaporization and convective heating with internal circulation; computational methods for spray flows; droplet interactions in a dense spray; development of liquid-fuel-film-combustion concept; turbine-burner concept with combustion in high-acceleration flows; vorticity dynamics perspective on liquid-stream instability and breakup. About 500 research papers and 300 research seminars and presentations. Details at http://mae.eng.uci.edu/Faculty/was/index.html

Awards and Recognitions: National Academy of Engineering; AIAA Wyld Propulsion Award, Propellants and Combustion Award, Energy Systems Award, Pendray Aerospace Literature Award, Sustained Service Award; ASME Freeman Scholar Award; Alfred C. Egerton Gold Medal, The Combustion Institute; IDERS Oppenheim Award. Fellow: AIAA, APS, ASME, AAAS, Soc. for Industrial & Applied Math,