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Frontiers in Experimental Observations of Detonation Properties with X-rays[1]

TREVOR WILLEY, Lawrence Livermore National Laboratory

Existing and emerging pulsed X-ray sources have the potential to resolve longstanding mysteries in detonation physics. In recent years, X-ray experimental capabilities have been developed and are beginning to interrogate fundamental physical and chemical kinetic properties on atomic to millimeter length scales over sub-nanosecond to microsecond timescales. Such phenomena include mechanisms of initiation, chemical kinetics, generated solid particulates including their morphologies and agglomeration kinetics, and void collapse with associated hot-spot formation; in most cases, theory and modeling have long preceded experimental capabilities. X-rays have Ångström wavelengths capable of probing crystal and molecular structure through diffraction, nano- and mesoscale morphology through scattering, and have the potential to image at sub-micron or even nanometer resolution, well beyond diffraction limited capabilities of, for example, optical imaging. X-rays ˜10 keV, or higher, penetrate relatively deeply into the bulk of low-Z, CHNO materials, making interrogation of self-propagating detonation fronts in centimeter-scale charges feasible. This talk will present an overview of the development of X-ray techniques implemented to experimentally observe detonation phenomena. We will highlight various results: imaging of operating detonators and initiation of detonation; characterization of the wide variety of carbonaceous particulates that form behind detonation fronts and their unexpected agglomeration kinetics, and frontier work interrogating chemistry and phase with, for example, dynamic diffraction and other techniques.

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