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Implementation of an ultrafast x-ray imaging camera for imaging shockwave evolution in defect-bearing ablator materials

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The quality of dynamic, nanosecond-scale imaging of micro-voids in ablator materials subjected to laser-driven shock compression is currently limited by low temporal resolution, which is crucial in determining factors that prevent ignition in inertial confinement fusion (ICF) experiments. At the Matter in Extreme Conditions (MEC) instrument at the Linac Coherent Light Source (LCLS), we utilized the XFEL multi-pulse mode, delivering four nanosecond-separated pulses to a single sample impacted by a high-intensity laser shockwave. We exploited the capabilities of an ultrafast x-ray imager (UXI), the Icarus V2, to capture multiple frames of microstructural evolution and void compression in a direct imaging geometry. To account and correct for the low- and high-frequency variations that are introduced into our images because of the stochastic nature of the XFEL and lens induced defects, we incorporated principal component analysis (PCA) and image alignment. Flat-field corrected images generated by the combination of these techniques are used as comparison to 2D radiation hydrodynamic simulations, yielding insights on void-shock response on ICF-relevant time scales. To quantitatively understand how the material structure evolves over several nanoseconds, we also implement a transport-of-intensity (TIE) based method to extract the mass density of our images and confirm that it is quantitatively comparable to hydrodynamic simulations.

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