Three-Dimensional Reconstruction of Direct-Drive Hot Spots from X-Ray and Nuclear Diagnostics on OMEGA

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Multidimensional effects on the hot-spot formation could limit the performance of direct-drive inertial confinement fusion experiments. Implosion performance was observed to be reduced due to mode-1 perturbations [1], but the effect of mode-2 perturbations on implosion performance needs a closer examination. A comprehensive 3-D reconstruction effort has been established at the Laboratory for Laser Energetics to infer hot-spot and shell conditions at stagnation from a collection of four x-ray and nine neutron detectors distributed around the target chamber. The neutron diagnostics provide measurements of hot-spot flow velocity, ion temperature distribution, and areal-density variation to diagnose mode-1 perturbations [2]. The time-gated and time-integrated x-ray imagers record the shape of the hot-spot plasma to diagnose mode-2 perturbations [3–9]. A deep-learning convolutional neural network [10] trained on 3-D radiation-hydrodynamic simulations [11] is used to interpret x-ray and nuclear measurements to infer 3-D emissivity, mass density, electron and ion temperature of the hot spot. A comparison of the hot-spot flow velocity distributions inferred from the neural network and the nuclear measurements is made to evaluate the accuracy of the reconstruction. A database of 10 layered deuterium–tritium (DT) cryogenic implosions was examined and the effects of mode 1 and mode 2 on the implosion performance will be presented. The results of a low-mode sensitivity study of laser-drive asymmetries on DT gas-filled plastic shell implosions will also be discussed. The mode-1 and mode-2 asymmetries were imposed with initial target offsets of spherically symmetric shells (mode 1) and contoured shell targets (mode 2).

This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] University of Rochester "National Inertial Confinement Fusion Program" under Award Number DE-NA0004144.

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