In-flight Asymmetry Growth in Low Peak-ρR Implosions at the NIF

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Controlling low-mode symmetry is one of the fundamental challenges of Inertial Confinement Fusion (ICF) and metrics have been developed on inflight shell symmetry to diagnose experiments at the National Ignition Facility [1]. In implosions with deuterium-^{3}He fuel, emitted fusion products provide measurements of in-flight areal density (ρR) asymmetry growth between peak velocity and peak compression along many lines of sight. D-^{3}He fusion produces protons with initial energy of 14.7 MeV and reaction history spanning from the first shock reaching the center of the implosion ('shock flash') to peak fuel compression ('compression-bang'): a period of 0.4—0.8 ns during which the ρR changes rapidly. The energy loss of the protons depends mainly on the time-varying ρR, such that proton spectra encode ρR evolution along the detector line-of-sight [2]. Data from multiple Wedge-Range-Filter proton spectrometers [3] are interpreted using a model relating proton energy and implosion ρR [4] to infer the evolution of ρR asymmetries. This new technique non-perturbatively probes the relative asymmetry growth between various lines of sight at convergences ~ 2—8 in implosions with peak ρR ≲ 350 mg/cm^2. Combining these data with an absolute measurement of the shock-flash timing [5] provides a powerful constraint on implosion models.

Proton spectral data has been obtained on the pole (θ=0, φ=0) and equator (90,78) of the NIF chamber for several sub-scale experiments with high-density carbon (HDC) ablators. Comparison between these lines of sight on the "BigFoot" shot N150809 reveals growth of a large l=2 mode (prolate), in quantitative agreement with self-emission hotspot x-ray images at peak convergence as well as hydrodynamic simulations. Proton data for further experiments reveal a sensitivity to asymmetry swings between shock- and compression-bang time, and suggest azimuthal ρR asymmetries similar to those reported by nuclear activation diagnostics on cryogenic-DT implosions [6]. Proton fluences recorded at the pole suggest time-varying, azimuthally-dependent magnetic fields near the laser entrance hole on the order of megaGauss. Comparisons between experimental data and simulations will be presented. This work performed under the auspices of the U.S. DoE by LLNL under Contract DE-AC52-07NA27344.

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