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Contents

In Brief

This volume of the LLE Review, covering October–December 2008, features "Demonstration of the Shock-Timing Technique for Ignition Targets at the National Ignition Facility" by T. R. Boehly, V. N. Goncharov, S. X. Hu, J. A. Marozas, T. C. Sangster, D. D. Meyerhofer (LLE), D. Munro, P. M. Celliers, D. G. Hicks, G. W. Collins, H. F. Robey, O. L. Landen (LLNL), and R. E. Olson (SNL). In this article (p. 1) the authors report on a technique to measure the velocity and timing of shock waves in a capsule contained within hohlraum targets. This technique is critical for optimizing the drive profiles for high-performance inertial-confinement-fusion capsules, which are compressed by multiple precisely timed shock waves. The shock-timing technique was demonstrated on OMEGA using surrogate hohlraum targets heated to 180 eV and fitted with a re-entrant cone and quartz window to facilitate velocity measurements using velocity interferometry. Cryogenic experiments using targets filled with liquid deuterium further demonstrated the entire timing technique in a hohlraum environment. Direct-drive cryogenic targets with multiple spherical shocks were also used to validate this technique, including convergence effects at relevant pressures (velocities) and sizes. These results provide confidence that shock velocity and timing can be measured in NIF ignition targets, thereby optimizing these critical parameters.

Additional highlights of recent research presented in this issue include the following:

- V. A. Smalyuk, R. Betti, T. R. Boehly, R. S. Craxton, J. A. Delettrez, D. H. Edgell, V. Yu. Glebov, V. N. Goncharov, D. R. Harding, S. X. Hu, J. P. Knauer, F. J. Marshall, R. L. McCrory, P. W. McKenty, D. D. Meyerhofer, P. B. Radha, S. P. Regan, T. C. Sangster, W. Seka, R. W. Short, S. Skupsky, J. M. Soures, C. Stoeckl, B. Yaakobi (LLE), D. Shvarts (Nuclear Research Center, Negev, Israel), J. A. Frenje, C. K. Li, R. D. Petrasso, and F. H. Séguin (Plasma Science Fusion Center, MIT) review recent progress in direct-drive, cryogenic implosions at the Omega Laser Facility (p. 12). Ignition-relevant areal densities of ~200 mg/cm^2 in cryogenic D_2 implosions with peak laser-drive intensities of ~5×10^{14} W/cm^2 were previously reported. The laser intensity is being increased to ~10^{15} W/cm^2 to demonstrate ignition-relevant implosion velocities of 3 to 4×10^7 cm/s, providing an understanding of the relevant target physics. Planar-target acceleration experiments show the importance of the nonlocal electron-thermal-transport effects for modeling the laser drive. Nonlocal, hot-electron preheat is observed to stabilize the Rayleigh–Taylor growth at the peak drive intensity of ~10^{15} W/cm^2. The shell preheat caused by the hot electrons generated by two-plasmon-decay (TPD) instability was reduced by using Si-doped ablators. The measured compressibility of planar plastic targets driven with high-compression, shaped pulses agrees well with 1-D simulations at these intensities. Shock mistiming has contributed to compression degradation of recent cryogenic implosions driven with continuous pulses. Multiple-picket (shock-wave) target designs make it possible for a more robust tuning of the shock-wave arrival times. Cryogenic implosions driven with double-picket pulses demonstrate improved compression performance at a peak drive intensity of ~10^{15} W/cm^2.

- J. A. Frenje, C. K. Li, F. H. Séguin, D. T. Casey, R. D. Petrasso (Plasma Science Fusion Center, MIT), T. C. Sangster, R. Betti, V. Yu. Glebov, and D. D. Meyerhofer (LLE) describe a new method for analyzing the spectrum of knock-on deuterons (KOd's) elastically scattered by primary DT neutrons, from which a fuel ρR can be inferred for values up to ~200 mg/cm^2 (p. 20). This new analysis method, which used Monte Carlo modeling of a cryogenic DT implosion, significantly improves the previous analysis method in two fundamental ways: First, it is not affected by significant spatial-yield variations, which degrade the diagnosis of fuel ρR (spatial-yield variations of about ±20% are typically observed), and secondly, it does not break down when the fuel ρR exceeds ~70 mg/cm^2.

- F. J. Marshall, P. W. McKenty, J. A. Delettrez, R. Epstein, J. P. Knauer, V. A. Smalyuk (LLE), J. A. Frenje, C. K. Li, R. D. Petrasso, F. H. Séguin (Plasma Science Fusion Center, MIT), and R. C. Mancini (Department of Physics, University of Nevada, Reno, Nevada) describe a method from which the cold fuel layer density is inferred from framed x-ray radiographs of a laser-driven spherical implosion (p. 26). The density distribution is determined by using Abel inversion to compute the radial distribution of the opacity κ from the observed optical depth τ. With the additional assumption of the mass of the remaining cold fuel, the absolute density distribution can be determined. This is demonstrated on the Omega Laser Facility with two x-ray backlighters of different mean energies that lead to the same inferred density distribution independent of backlighter energy.

- A. A. Solodov, K. S. Anderson, R. Betti, V. Gotcheva, J. Myatt, J. A. Delettrez, S. Skupsky, W. Theobald, and C. Stoeckl (LLE) present integrated simulations of implosion, electron transport, and heating for direct-drive fast-ignition targets (p. 31). A thorough understanding of future integrated fast-ignition experiments combining compression and heating for high-density thermonuclear fuel requires hybrid (fluid + particle) simulations of the implosion and ignition process. Different spatial and temporal scales need to be resolved to model the entire fast-ignition experiment. The two-dimensional (2-D) axisymmetric hydrocode *DRACO* and the 2-D/three-dimensional hybrid-PIC code *LSP* have been integrated to simulate the implosion and heating of direct-drive, fast-ignition targets. *DRACO* includes the physics required to simulate compression, ignition, and burn of fast-ignition targets. *LSP* simulates the transport of hot electrons from their generation site to the dense fuel core where their energy is absorbed. The results from integrated simulations of cone-in-shell CD targets designed for fast-ignition experiments on the OMEGA-OMEGA EP Laser System are presented. Target heating and neutron yields are computed. The results from *LSP* simulations of electron transport in solid-density plastic targets are also presented. They confirm an increase in the electron-divergence angle with the laser intensity in the current experiments. The self-generated resistive magnetic field is found to collimate the hot-electron beam and increase the coupling efficiency of hot electrons with the target. Resistive filamentation of the hot-electron beam is also observed.

- C. Miao, S. N. Shafrir, J. C. Lambropoulos, J. Mici, and S. D. Jacobs (LLE) report *in-situ*, simultaneous measurements of both drag and normal forces in magnetorheological optical finishing (MRF) using a spot-taking machine (STM) as a test bed to take MRF spots on stationary optical parts (p. 42). The force measurements are carried out over the entire removal area, produced by the projected area of the MRF removal function/spot on the part surface, using a dual-force sensor. This approach experimentally addresses the mechanisms governing material removal in MRF for optical glasses in terms of the hydrodynamic pressure and shear stress, applied by the hydrodynamic flow of magnetorheological (MR) fluid at the gap between the part surface and the STM wheel. This work demonstrates that the volumetric removal rate shows a positive linear dependence on shear stress. Shear stress exhibits a positive linear dependence on a material figure of merit that depends on Young's modulus, fracture toughness, and hardness. A modified Preston's equation is proposed that will better estimate MRF material removal rate for optical glasses by incorporating mechanical properties, shear stress, and velocity.

- L. Sun, J. D. Zuegel, J. R. Marciante (LLE), and S. Jiang (AdValue Photonics, Inc.) propose and experimentally validate the concept of effective Verdet constant to describe the Faraday rotation characteristics of optical fiber (p. 51). The effective Verdet constant of light propagation in fiber includes contributions from the materials in both the core and the cladding. This article presents a measured Verdet constant in 25-wt% terbium-doped-core phosphate fiber to be -6.2 ± 0.4 rad/Tm at a wavelength of 1053 nm, which is $6\times$ larger than in silica fiber. The result agrees well with the Faraday rotation theory for optical fiber.

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Editor