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Contents

In Brief

This volume of the LLE Review, covering October–December 2009, features "Demonstration of the Highest Deuterium–Tritium Areal Density Using Triple-Picket Cryogenic Designs on OMEGA" by V. N. Goncharov, T. C. Sangster, T. R. Boehly, S. X. Hu, I. V. Igumenshchev, F. J. Marshall, R. L. McCrory, D. D. Meyerhofer, P. B. Radha, W. Seka, S. Skupsky, and C. Stoeckl. This article (p. 1) reports the performance of triple-picket deuterium–tritium (DT) cryogenic target designs on the OMEGA Laser System. These designs allow for improved control of shock heating in low-adiabat inertial confinement fusion implosions. Areal densities up to 300 mg/cm^2, the highest ever measured in cryogenic-DT implosions, are inferred in these experiments. Extension of these designs to ignition on the National Ignition Facility is presented.

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

- M. A. Barrios, D. G. Hicks, T. R. Boehly, D. E. Fratanduono, and D. D. Meyerhofer (LLE) and J. H. Eggert, P. M. Celliers, and G. W. Collins (LLNL) present measurements of the equations of state (EOS) of polystyrene and polypropylene using laser-driven shock waves with pressures from 1 to 10 Mbar (p. 6). Precision data resulting from the use of α-quartz as an impedance-matching (IM) standard tightly constrain the EOS of these hydrocarbons, even with the inclusion of systematic errors inherent to IM. The temperature at these high pressures was measured, which, combined with kinematic measurements, provides a complete shock EOS. Both hydrocarbons were observed to reach similar compressions and temperatures as a function of pressure. The materials were observed to transition from transparent insulators to reflecting conductors at pressures of 1 to 2 Mbar.

- P.-Y. Chang, R. Betti, K. S. Anderson, and R. Nora (LLE and FSC); R. L. McCrory (LLE); B. K. Spears, J. Edwards, and J. D. Lindl (LLNL); M. Fatenejad (University of Wisconsin, Madison); and D. Shvarts (Nuclear Research Center Negev) derive a multidimensional, measurable ignition condition for thermonuclear ignition of inertial confinement fusion capsules (p. 22). The ignition criterion accounts for the effects of implosion nonuniformities and depends on three measurable parameters: the neutron-averaged total areal density, the ion temperature, and the yield-over-clean (YOC = ratio of the measured neutron yield to the predicted one-dimensional yield). The YOC measures the implosion uniformity. The criterion can be approximated as $\chi = \rho R_{\mathrm{n}}^{\mathrm{tot}} \left(T_{\mathrm{n}}/4.7\right)^{2.1} \mathrm{YOC}^{\mu} > 1$ (where ρR is in g/cm^2, T is in keV, and $\mu \approx 0.47$ to 0.63) and can be used to assess the performance of cryogenic implosions on the NIF and OMEGA. The validity of this criterion is confirmed by a multicode simulation database. Cryogenic implosions on OMEGA have achieved $\chi \sim 10^{-2}$.

- J. Qiao, A. W. Schmid, L. J. Waxer, T. Nguyen, J. Bunkenburg, C. Kingsley, A. Kozlov, and D. Weiner describe a grating-inspection system and a damage-analysis method developed to measure *in-situ* laser-induced damage on a 1.5-m tiled-grating assembly of the OMEGA EP pulse compressor during a 15-ps, 2.2-kJ energy ramp (p. 27). The beam fluence at which significant damage growth occurred was determined. This is the first report on beam fluence versus laser-induced–damage growth of meter-sized multilayer-dielectric-diffraction gratings. This result was correlated to the damage-probability measurement conducted on a small grating sample and is consistent with the fluence corresponding to 100% damage probability.

- J. A. Frenje, D. T. Casey, C. K. Li, F. H. Séguin, and R. D. Petrasso (Plasma Science and Fusion Center, MIT); V. Yu Glebov, P. B. Radha, T. C. Sangster, and D. D. Meyerhofer (LLE); S. P. Hatchett, S. W. Haan, C. J. Cerjan, and O. L. Landen (LLNL); K. A. Fletcher (State University of New York at Geneseo); and R. J. Leeper (Sandia National Laboratories) probe high-areal-density (ρR) cryogenic-DT implosions using down-scattered neutron spectra measured with the magnetic recoil spectrometer (MRS) recently installed and commissioned on OMEGA (p. 33). The ρR data obtained with the MRS have been essential for understanding how fuel assembly occurs and for guiding the cryogenic program at LLE to ρR values up to ~300 mg/cm^2. Areal-density data obtained from the well-established charged-particle–spectrometry technique were used to authenticate the MRS data, and the ρR values inferred from these two techniques are similar, indicating that the MRS technique provides high-fidelity ρR data. Recent OMEGA MRS data and Monte Carlo simulations have shown that the MRS at the National Ignition Facility will meet most of the absolute and relative requirements for determining ρR, ion temperature (T_i), and neutron yield (Y_n) in both low-yield, deuterium-lean, H-doped tritium–hydrogen–deuterium implosions and high-yield deuterium–tritium implosions.

- S. X. Hu, V. N. Goncharov, and S. Skupsky (LLE) and B. Militzer (University of California, Berkeley) derive a first-principles equation of state (FPEOS) table for deuterium using the path-integral Monte Carlo method (p. 44). Accurate knowledge about the equation of state (EOS) of deuterium is critical to inertial confinement fusion (ICF). Low-adiabat ICF implosions routinely access strongly coupled and degenerate plasma conditions. The FPEOS table covers typical ICF fuel conditions at densities ranging from 0.002 g/cm^3 to ~1600 g/cm^3 and temperatures of 1.35 eV to 5.5 keV. Discrepancies in internal energy and pressure have been found in strongly coupled and degenerate regimes with respect to *SESAME* EOS. Hydrodynamics simulations of cryogenic ICF implosions using the FPEOS table have indicated significant differences in peak density, areal density (ρR), and neutron yield relative to *SESAME* simulations. The FPEOS simulations result in better agreement of compression ρR with experiments.

- M. C. Ghilea, D. D. Meyerhofer, and T. C. Sangster present a theoretical model to describe the mechanism of bubble formation for Freon 115 as the active medium in a liquid bubble chamber (p. 50). Neutron imaging is used in inertial confinement fusion (ICF) experiments to measure the core symmetry of imploded targets. Liquid bubble chambers have the potential to obtain higher-resolution images of the targets for a shorter source–target distance than typical scintillator arrays. The bubble-formation model shows that the size of the critical radius for the nucleation process determines the mechanism of bubble formation and the sensitivity of the active medium for the 14.1-MeV incident neutrons resulting from ICF implosions. The bubble-growth mechanism is driven by the excitation of the medium electronic levels and not by electrons ejected from the medium's atoms as happens for the bubble chambers used to detect charged particles. The model accurately predicts the neutron-induced bubble density measured on OMEGA with liquid bubble chambers and gel detectors.

Kenneth S. Anderson
Editor