March 2007 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

Polar-Direct-Drive Ignition Design: LLE is working to validate use of the NIF in the x-ray-drive configuration for direct-drive-ignition experiments. This work indicates that polar direct drive (PDD) is a viable and attractive option for ignition on the NIF. Numerical simulations using the 2-D hydrodynamics code *DRACO* achieve ignition with all sources of nonuniformity included. The standard PDD illumination scheme[1] repoints and reshapes the NIF beams to minimize illumination nonuniformities arising from the absence of equatorial beams in the x-ray-drive laser configuration. In contrast to the all-DT design,[2] this ignition design incorporates a DT, wetted-foam ablator, that increases the laser absorption because of the carbon ions in the ablator material. The increase in absorbed energy compensates for the refractive losses from the oblique, repointed NIF beams in the equatorial regions of the target. This design has undergone significant 2-D modeling to examine the effects of PDD illumination and the other main perturbation sources (inner- and outer-surface roughness, power imbalance, and laser imprint). In all cases, ignition was obtained with gains ranging from 15 to 20. Figure 1 shows a schematic of the target, as well as density and temperature contours near the time of ignition. These contours are from a 2-D simulation that includes all sources of nonuniformity. The simulation uses 2-D SSD beam smoothing (1-THz, two-color cycles) and takes into consideration all current NIF direct-drive-system specifications for sources of perturbations, including 8% beam-to-beam power imbalance, 100-nm outer-surface roughness, and a 1-μm-rms inner-surface roughness with less than 0.25-μm rms contained in modes greater than 10. Even with a distorted core, there is a significant hot-spot region with ion temperatures in excess of 10 keV leading to a gain of ~17. Work is also underway to optimize an alternative PDD approach to ignition using the SATURN concept.[3] This work completes a DOE level 2 milestone.

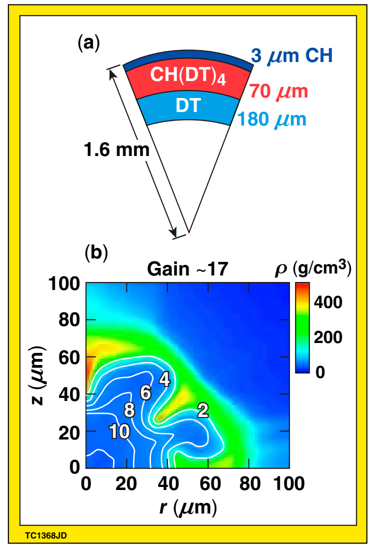

Figure 1. (a) A schematic of the PDD target. (b) The density and temperature contours near the time of ignition. This schematic is from a 2-D simulation that includes all sources of nonuniformity and is ignited with a gain of 17. The white temperature contours are in keV.

Indirect-Drive Implosion Symmetry Campaign: In a joint LLE/LLNL experiment, the symmetry of imploding capsules driven with gas-filled, scale-1, Au hohlraums was measured on OMEGA using phase plates in the drive beams. This is the first such measurement in a multicone geometry.[4] Axial and radial gated x-ray images were recorded with low magnification (2×) for the hohlraum plasma and with high magnification (12×) for the implosion. As shown in Fig. 2(a), oblate implosions were observed in radial views for gas-filled hohlraums ($n_e = 4 \times 10^{20}$ cm^{-3}), while vacuum hohlraums produced more symmetric implosions [Fig. 2(b)]. Gated x-ray images of the implosion taken along axial views were symmetric. The measured primary neutron yields averaged 7.4×10^8 for vacuum hohlraums and 5.4×10^8 for gas-filled hohlraums and peak radiation temperature averaged 193 eV for vacuum hohlraums and 188 eV for gas-filled hohlraums.

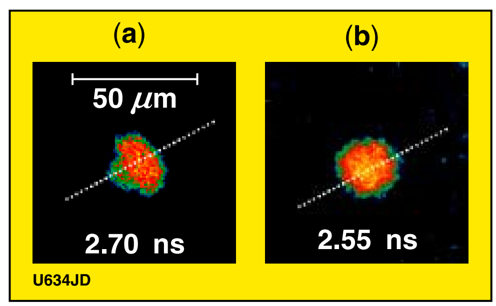

Figure 2. Measured gated (~30 ps) x-ray (hν > 3 keV) images of an imploding capsule (Ge-doped CH/PVA/PAMS) filled with Ar-doped deuterium taken along a radial view for (a) a hohlraum plasma with $n_e = 4 \times 10^{20}$ cm^{-3} and (b) a vacuum hohlraum. The white dotted line represents the hohlraum axis. The gas-filled hohlraum produces an oblate implosion, while the vacuum hohlraum produces a more symmetric one.

OMEGA Operations Summary: The OMEGA Laser Facility conducted 136 target shots in March with an overall shot effectiveness of 90.8%. The indirect-drive-ignition campaign (IDI NIC) accounted for 68 target shots (41 shots led by LLNL and 27 by LLE). LLE scientists took 22 shots for the direct-drive-ignition campaign (DDI NIC). There was also a total of 30 target shots for three NLUF experimental teams led by MIT, the University of Michigan, and Rice University; and LLNL carried out 16 HED experiments.

1. S. Skupsky *et al*., Phys. Plasmas **11**, 2763 (2004).
2. P. W. McKenty *et al*., Phys. Plasmas. **11**, 2790 (2004).
3. R. S. Craxton and D. W. Jacobs-Perkins, Phys. Rev. Lett. **94**, 095002 (2005).
4. N. D. Delamater *et al*., Phys. Plasmas **7**, 1609 (2000).

Contact: John M. Soures (585) 275-3866; fax: (585) 256-2586; e-mail: jsou@lle.rochester.edu