August 1997 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Summary: During the reporting period, OMEGA supported hohlraum physics experiments conducted by LLNL and LANL scientists. Planar-foil Rayleigh–Taylor (RT) experiments (S1/S2) were continued, and a new 12-beam high-dynamic-range optical streak camera was implemented on OMEGA. Calculations carried out by LLE scientists suggest that dynamic stabilization of the Rayleigh–Taylor instability may ameliorate the effects of this instability on ICF capsule performance.

Dynamic Stabilization of Cryogenic Capsules: Modeling carried out by LLE theoreticians suggests that dynamic stabilization of the RT instability during NIF cryogenic capsule implosions may be possible. The dynamic stabilization is induced by modulating the laser intensity to generate large-amplitude oscillations of the ablation-front acceleration resulting from rapid compression and decompression of the shell. Reduced instability-induced shell perturbations are predicted compared to unmodulated pulses. While the isentrope of the implosion is modified by the use of dynamic stabilization, ignition and gains in excess of 10 were achieved. The optimum laser amplitude modulation period for NIF is about 700 ps with a modulation depth $\geq$ 60% rms.

Indirect-Drive ICF Campaign (ID3, ID4): During August, LLE supported two weeks of experiments on the physics of cylindrical (LLNL-ID3) and tetrahedral (LANL-ID4) hohlraums. A total of 50 shots were taken for these two campaigns. During the LLNL series, some previous experiments on x-ray drive symmetry using "sym-caps" and "foam ball" targets were repeated and refined. A new backlighter configuration was successfully tested that improved imaging, required less beam energy, and allowed longer backlighter exposures. Simulated glint exposures (i.e., direct laser irradiation of the capsule) were carried out by placing one of the OMEGA beams directly on the target inside the hohlraum. The LANL experiments investigated drive symmetry using spherical hohlraums with four laser entrance holes (LEH); these are designated as "tetrahedral hohlraums." In this configuration all 60 beams of OMEGA can be used to irradiate the hohlraum. Hohlraums of different diameters and different hohlraum-to-LEH diameter ratios were used for these experiments.

Multiple-Beam UV Pulse Shape Measurements: To meet the ICF capsule drive uniformity requirements, OMEGA must provide nearly identical energies and pulse shapes in all the beamlines. The harmonic energy detector (HED) measures each beam's energy to a precision of <0.5% rms. Until now, however, the UV pulse shapes could be monitored only on two beamlines with limited-bandwidth photodiodes. We have significantly improved the UV pulse shape monitoring on OMEGA by activating the first 12-channel UV streak camera. The camera simultaneously measures the pulse shapes of all the beams (10) in a single OMEGA cluster and provides two fiducial channels for timing and calibration. Data are routinely collected on each shot, and a preliminary analysis indicates that the camera's dynamic range is several hundred to one and the signal-to-noise ratio at pulse peak power is ~1% rms. This instrument is an important step toward achieving precision power balance on OMEGA.

Planar Rayleigh–Taylor Experiments (S1/S2): The data collected during the July shots for the planar-target Rayleigh–Taylor instability experiments have been analyzed to determine the growth versus time for perturbations with initial wavelengths of 60, 31, and 20 μm (Fig. 1). The data demonstrate the high reproducibility of the radiographic measurements. The signal-to-noise ratio of the experimental data has been increased by optimizing the filtering of the framing camera and the thickness of the debris shield between the uranium backlighter and the accelerated foil. In these experiments 20-μm-thick CH foils with imposed mass perturbations (0.9 μm peak-to-valley) were irradiated at 2×10^{14} W/cm^2. The target acceleration was ~100 μm/ns^2. These parameters along with the measured laser intensity are used as the initial conditions for the 2-D hydrodynamic simulations of these experiments.

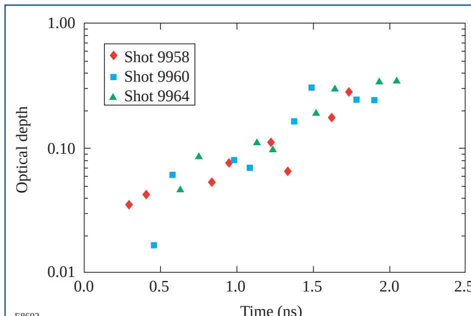

Fig. 1. Plot of measured optical depth as a function of time for three planar-foil experiments with a 31-μm initial perturbation wavelength.

OMEGA Operations Summary: OMEGA provided 65 target shots for ID3, ID4, and S1/S2 experiments. In addition, quarterly maintenance activities were conducted and several facility improvements were implemented, including the installation of the new diode-pumped monomode oscillator and improved laser diagnostics, deployment of new control systems and timing system, and modifications to the target chamber vacuum system.

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