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

Summary: During the reporting period we conducted spherical- and planar-target Rayleigh–Taylor experiments and long-scale-length plasma interaction experiments on OMEGA; implemented new OMEGA target diagnostics; extended the 2-D SSD beam-smoothing system to higher bandwidth; and conducted final acceptance tests of OMEGA's new oscillator system.

Planar-Target Rayleigh–Taylor Experiments: During the months of June and July 1997, 58 shots were taken on OMEGA for the planar-target Rayleigh–Taylor (RT) and imprinting (S1/S2) campaigns. These shots were split evenly between actual growth-rate measurements and diagnostic improvements to achieve better signal-to-noise ratio and higher contrast in measurements of the foil x-ray transmission. Experiments were conducted with imposed mass perturbations with spatial wavelengths of 20, 31, and 60 μm. We used x-ray framing cameras as the prime diagnostics and also evaluated an improved Kirkpatrick–Baez (KB) x-ray microscope. On some targets, a polystyrene foam buffer layer was used to evaluate imprint mitigation and RT growth-rate reduction due to the foam. Excellent data was obtained that will be used to perform detailed comparisons between the experimental measurements and *ORCHID* 2-D hydrocode simulations. We used a new set of phase plates (DPP's) that were designed to produce an $\exp[-(r/r_0)]^{3.5}$ envelope on the drive beams. In addition, the drive beams were outfitted with distributed polarization rotators (DPR's) for the first time and used 2-D SSD with a bandwidth of 1.2 Å × 1.7 Å (in the IR). The resulting drive configuration represents the best drive uniformity ever used on OMEGA flat-target experiments. LANL scientists collaborated on these experiments.

Diagnostics Development—Imaging the Cold, Compressed Shell: Due to its weak x-ray emission, the cold, compressed shell in laser-driven implosions can be normally imaged only by x-ray backlighting. However, a high-*Z*-doped shell can be imaged using the Kα line radiation, which fluoresces due to excitation by the intense radiation from the hot core. On specially designed, titanium-doped imploding targets irradiated on OMEGA, we used the 1-D spatial profile of the Ti Kα radiation to determine the dimensions of the cold pusher shell at the time of peak compression (Fig. 1). This result, coupled with the measurement of the shell areal density via *K*-edge absorption, yielded an estimate of the shell density.

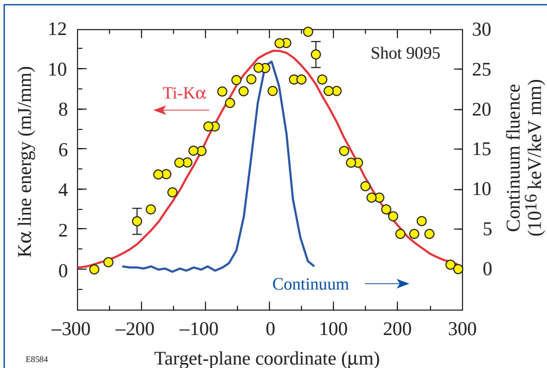

Fig. 1 A comparison of the spatial profiles of the Ti-Kα (the cold shell) and the 4.2- to 4.4-keV continuum band (the hot core) for a specially constructed 931-μm-outer-diam empty CD shell.

Diagnostics Development—Neutron Burn History and Bang Time: Activation of the streak-camera-based Neutron Temporal Diagnostic (NTD) from LLNL was completed, and the instrument was used to measure neutron burn histories on recent DT-filled (PP2) and DD-filled (S3) target experiments. For sufficiently high neutron-yield experiments, NTD is capable of high temporal resolution (~30 ps) and absolute timing relative to the laser drive pulses (~100 ps). NTD will be routinely available for OMEGA shots. A neutron "bang time" diagnostic has been implemented that measures the onset of neutron emission for targets with neutron yields substantially below the threshold of NTD. This instrument has lower temporal resolution but complements NTD.

High-Bandwidth 2-D SSD Tests on OMEGA: During the past month large-bandwidth (1.5-Å × 2.05-Å FM bandwidth) pulses were propagated at full energy through the OMEGA laser system. Spectral clipping of the laser pulses at the spatial filter pinholes was of particular concern, but experiments using several different diagnostics showed no detectable clipping. The system was subsequently cleared for routine operation at 1.25-Å × 1.75-Å bandwidth. At this bandwidth a 5% to 10% temporal far-field amplitude modulation was observed in the full-system UV output. The source of this modulation is presently under investigation. Pending this investigation, we will clear the system for 1.5-Å × 2-Å operation.

New Diode-Pumped Master Oscillator for OMEGA: Final acceptance tests of the single-frequency, diode-pumped, pulsed Nd:YLF laser were conducted during the reporting period. This laser was designed for high reliability and low maintenance. It will replace OMEGA's existing flash-lamp-pumped monomode laser within a month. The new laser generates 100-nJ, 20-ns flat-top square pulses for each of the four pulse-shaping channels that subsequently shape the laser pulses for propagation through the OMEGA amplifier chains and the fiducial laser. The diode-pumped laser incorporates amplitude and frequency stability feedback control systems and has demonstrated excellent frequency (mode) stability over many hours of operation.

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