January 2012 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

Multifrequency-Modulated Smoothing by Spectral Dispersion: Single-beam laser smoothing is crucial for direct-drive ICF experiments. Laser-driven nonuniformities cause imprinting of short- and long-wavelength mass modulations at the ablation surface of the target. These modulations grow during shell acceleration as a result of the Rayleigh–Taylor (RT) instability and can lead to shell failure and a significant reduction of target performance. One-dimensional, multi-FM (mFM) smoothing by spectral dispersion (SSD) has been developed at LLE[1] to provide the required level of smoothing for the current NIF polar-drive–ignition point design.[2] To demonstrate the efficacy of mFM beam smoothing before implementation of this system on the NIF, a prototype mFM seed source was installed and activated on Beam 4 of the OMEGA EP laser and is being qualified for a target experiment.

Equivalent-target-plane (ETP) measurements of the ultraviolet irradiation uniformity of a mFM smoothed pulse have been performed. Results for the far-field of an OMEGA EP SG8-1100 distributed phase plate (DPP) irradiated with a 150-ps pulse, with and without mFM smoothing applied, are shown in Fig. 1. The white lines are central lineouts of the far-field intensity distribution in the horizontal and vertical directions. Figure 1(a) shows the highly modulated spatial-intensity profile for a pulse without mFM SSD. To suppress stimulated Brillouin scattering (SBS), some beam smoothing was applied for this case via the SBS suppression (SBSS) system. In contrast, the data in Fig. 1(b) with applied mFM SSD exhibits a significantly smoother envelope in both directions. As a result of the 1-D nature of the mFM system, smoothing is applied predominantly in the *x* direction in Fig. 1(b). Nevertheless, the intensity lineouts show effective smoothing in both the *x* and *y* directions. A detailed analysis of the ETP data and a comparison to the theoretical predictions are in progress.

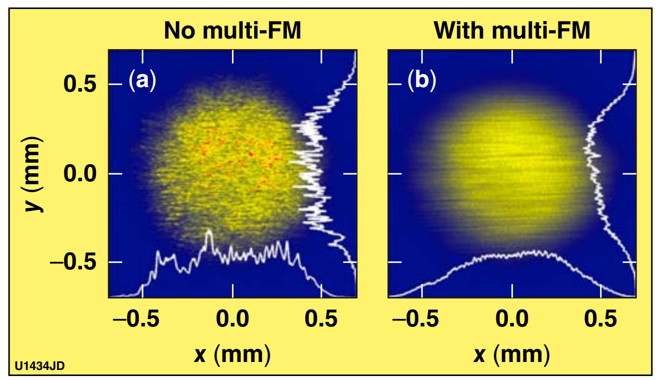

Figure 1. Experimental-equivalent-target plane measurements to assess multi-FM SSD performance. The white lines are horizontal and vertical lineouts through the center of the intensity profiles. (a) The far-field measurement with no mFM beam smoothing exhibits significant spatial-intensity modulations, whereas in (b) the intensity profile with mFM SSD is considerably smoother in both the horizontal and vertical directions.

Preliminary experiments have been performed to study the effect of mFM smoothing on laser imprinting. A planar CH foil was driven by Beam 4 using a 3-ns square pulse with an on-target intensity of ~10^{14} W/cm^2. These experiments were carried out with and without mFM smoothing applied to the laser pulse during the first 2 ns. The Rayleigh–Taylor amplified, broadband laser imprint was imaged through face-on x-ray radiography of the driven target, which provides an optical-density map of the modulated target. Examples for the extracted optical-density modulations without mFM smoothing applied and with mFM SSD are displayed in Figs. 2(a) and 2(b), respectively. Figure 2(c) shows preliminary results for the rms amplitude of the optical density as a function of time. The value for the mFM SSD is reduced to ~65% of the unsmoothed optical-density profile. Further experiments and analysis of the mFM performance using 2-D *DRACO* simulations are underway.

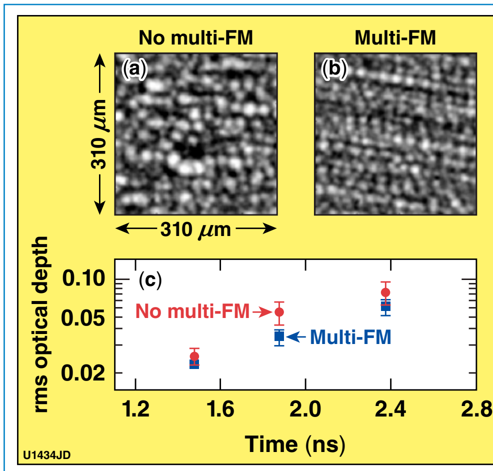

Figure 2. Optical-density modulations at 1.9 ns (a) without and (b) with mFM SSD beam smoothing applied. (c) rms amplitude of optical density as a function of time.

Omega Facility Operations Summary: The Omega Laser Facility conducted 134 target shots in January (123 shots on the OMEGA 60-beam laser and 11 on OMEGA EP, with an average experimental effectiveness of 95.1% and 100%, respectively). The NIC accounted for 58 target shots led by LLE scientists and the HED program conducted 9 target shots for an experiment led by LLNL. Forty-five target shots were carried out by three NLUF teams led by MIT, the University of Nevada, Reno, and Princeton University, respectively. An LLNL-led team conducted 11 target shots for an LBS experiment.

1. *LLE Review Quarterly Report* **114**, 73, Laboratory for Laser Eneregetics University of Rochester, NY, LLE Document No. DOE/NA/28302-826, (2008).
2. T. J. B. Collins *et al*., "A Polar-Drive–Ignition Design for the National Ignition Facility," to be published in Physics of Plasmas.