June 2012 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

Magnetic-Field Generation by Rayleigh–Taylor Instability: Understanding and control of Rayleigh–Taylor (RT) instability is essential for a high-performance ICF capsule implosion. Previous theoretical work showed that a plasma subject to RT instability should generate spontaneous magnetic fields, and recent OMEGA experiments studied magnetic-field generation in the linear regime of RT instability.[1] This month, magnetic-field generation induced by RT instability in an ablatively driven plasma was studied on the OMEGA EP Laser System using ultrafast laser-driven proton radiography. Thin plastic foils were irradiated with ~4-kJ, 2.5-ns laser pulses focused to 10^{14} W/cm^2. The driven foils were probed in a direction orthogonal to the main interaction with an ultrafast proton beam that revealed the magnetohydrodynamic (MHD) evolution of the targets. The target modulations were seeded by laser nonuniformities and amplified during the target-acceleration phase. These experiments show MG-level magnetic fields inside a laser-driven foil broken up by RT instability during the nonlinear growth phase.[2] Figure 1 shows proton radiographs from two different experiments with 15-μm-thick laser-driven CH foils. Electromagnetic fields provide a novel diagnostic of the bubble-like structures generated by RT instability. Larger-scale structures at $t = t_0 + 2.56$ ns indicate the field evolution. Figure 1 shows that an electric-field sheath forms at the plasma–vacuum interface. Numerical modeling with the 2-D resistive MHD code *DRACO*[3] supports the experimental observations. The *DRACO* calculations show that a 15-μm-thick foil is broken apart by RT instability, generating MG-level magnetic fields at RT unstable interface. Figure 2(a) shows the calculated target-density profile at $t = t_0 + 2.1$ ns. Density perturbations grown by RT instability are greater in extent than the target thickness, breaking the foil apart. Large density and temperature gradients form in this unstable plasma and spontaneously generate MG-level magnetic fields. Figure 2(b) shows the predicted magnetic-field distribution at $t = t_0 + 2.1$ ns. Overlaid on this field distribution is the calculated density contour for $\rho = 0.05$ g/cm^3, indicating the position of the target. *DRACO* predictions indicate that up-to-2-MG magnetic fields are generated in these conditions inside the driven foil. *DRACO* simulations indicate that the dynamic effect of the spontaneous magnetic fields on RT instability are negligible in the linear and moderately nonlinear stages of its evolution.

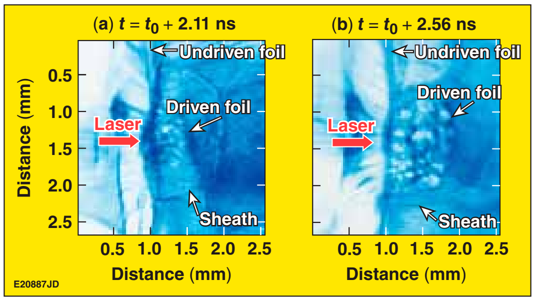

Figure 1. Proton radiographs of a 15-μm-thick CH foil taken with 13-MeV protons at (a) $t = t_0 + 2.11$ ns and (b) $t = t_0 + 2.56$ ns, where t_0 is the arrival time of the long-pulse beams at the CH-foil surface. The direction of the laser drive, the foil horizon, the unstable RT plasma, and the sheath field are indicated.

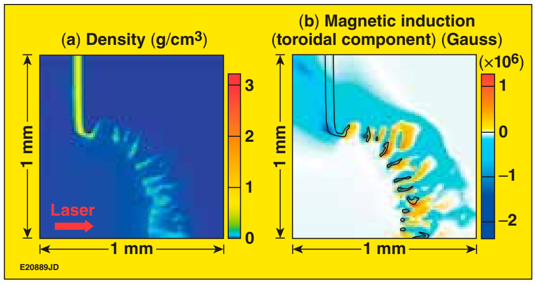

Figure 2. (a) Simulated density profile at $t = t_0 + 2.1$ ns. The modeled target is axisymmetric about the horizontal axis. (b) Self-generated magnetic-field distribution at $t = t_0 + 2.1$ ns. Overlaid in black is the density contour for $\rho = 0.05$ g/cm^3.

Omega Facility Operations Summary: The Omega Laser Facility conducted 144 target shots in June (113 on OMEGA with average effectiveness of 94.7% and 31 on OMEGA EP with average effectiveness of 96.8%).

The FY13 annual meeting of the Facility Advisory and Scheduling Committee (FASC) was held in June and established the Omega Laser Facility shot schedule through September 2013. The FASC allocated 114 shot days on OMEGA and 71 days on OMEGA EP—77% of full capacity limited by funding constraints. The requests for shot time exceeded time available in each category; notably, this is the first year that demand for OMEGA EP shot time was equal to the demand for OMEGA. Significant oversubscription was present in all campaign categories: Ignition, High Energy Density (HED), and Basic Science (NLUF and LBS). The allocation of shots followed NNSA guidance and resulted in an FY13 schedule with 35% Ignition, 30% HED, and 30% Basic Science, with 5% of shot days held in contingency.

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1. M. J.-E. Manuel *et al*., Phys. Rev. Lett. **108**, 255006 (2012).
2. L. Gao *et al*., "Magnetic-Field Generation by Rayleigh–Taylor Instability in Laser-Driven Planar Plastic Targets," to be published in Physical Review Letters.
3. D. Keller *et al*., Bull. Am. Phys. Soc. **44**, 37 (1999).

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