March 2014 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

Magnetized Inertial Confinement Fusion Implosions on OMEGA: If the hot spot of a compressed target is magnetized, the heat loss is reduced, leading to a higher hot-spot temperature and, therefore, higher neutron yield. Previous OMEGA experiments have shown that the ion temperature and neutron yield increased by ~15% and ~30%, respectively, when an 8-T seed magnetic field was embedded in a warm target and compressed using a 1-ns square pulse.[1] The seed magnetic field for these OMEGA experiments is externally provided by using the magneto-inertial fusion electrical discharge system (MIFEDS).[2]

Recent (2014) OMEGA experiments used a configuration similar to Ref. 1. Targets with an outer diameter of either 860 μm or 920 μm with ~22.5-μm plastic shell thickness and filled with 10 atm of D_2 gas were compressed using 40 OMEGA beams in the polar-drive configuration with 16 kJ on target. A shaped pulse was used to produce an adiabat of ~3.5 (lower than that of Ref. 1). A single coil on the equatorial plane (Fig. 1) provided a 7-T field. Simulations show that a self-generated field from the nonuniformity caused by the stalk[3] can be comparable to the compressed field[2] in the azimuthal direction. If the stalk is along the seed field direction, the field lines can be twisted like a helix and become longer in the hot spot, leading to lower heat loss. To observe this effect, targets were inserted either from TIM-1 (ten-inch manipulator), which is along the field direction, or from TIM-6, which is at 63° with respect to the field direction.

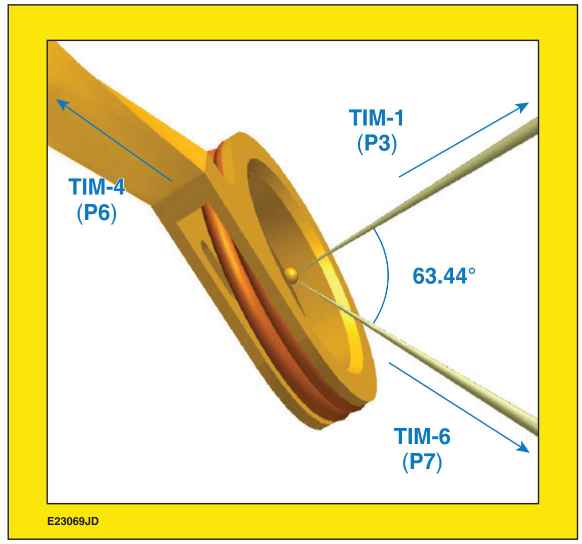

Figure 1. The experiment setup. The target is inserted either from TIM-1 (along the field direction) or TIM-6. TIM: ten-inch manipulator.

Figure 2 shows the observed neutron yield as a function of the shell thickness.[4] The observed neutron yield increases by >50% for magnetized targets with an outer diameter of 860 μm regardless of the stalk orientation. A multiple linear regression method was used to separate the effect of the magnetic field and the shell thickness. For 920-μm-diam targets, the average neutron yield increased by 14% in the presence of a magnetic field. The ion temperature for these shots varies from 2.2 keV to 2.9 keV. It appears to be more sensitive to the variation in target diameter and shell thickness than to the presence or absence of a magnetic field. Future experiments with more-uniform targets and higher magnetic fields will study the ion temperature dependence.

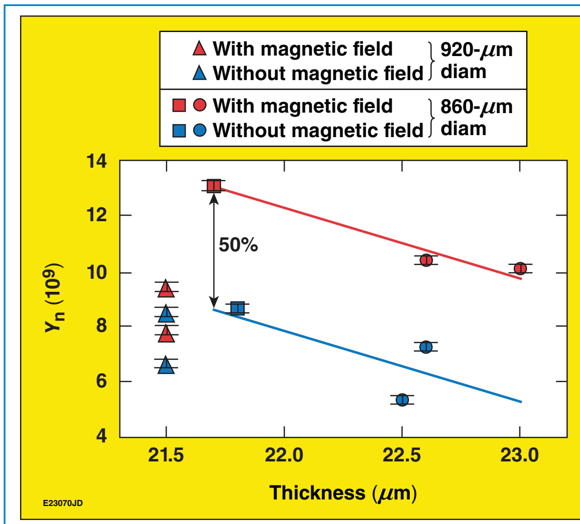

Figure 2. The data with and without magnetic fields are in red and blue, respectively. The circles and squares represent data for 860-μm-diam targets with the stalks aligned along the magnetic-field direction and aligned 63° with respect to the direction of the seed fields, respectively. The triangles represent data from the 920-μm-diam targets with the stalk along the seed field.

Omega Facility Operations Summary: The Omega Facility conducted 157 target shots in March 2014 with an average experimental effectiveness of 94.6% (95 on the OMEGA laser with an effectiveness of 95.3% and 62 on OMEGA EP with an effectiveness of 93.5%). The ICF and HED programs accounted for 99 and 37 target shots, respectively, for experiments led by LANL, LLE, and LLNL. One NLUF experiment led by Princeton University carried out eight target shots and two LBS experiments led by LLNL conducted 13 target shots during the reporting period. Through the second quarter of FY14, the Omega Facility has carried out 924 target shots with an average experimental effectiveness of 93.9%.

1. P. Y. Chang *et al.*, Phys. Rev. Lett. **107**, 035006 (2011).
2. O. V. Gotchev *et al.*, Phys. Rev. Lett. **103**, 215004 (2009).
3. I. V. Igumenshchev *et al.*, Bull. Am. Phys. Soc. **58**, 324 (2013).
4. F. J. Marshall *et al.*, Phys. Plasmas **7**, 1006 (2000).

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