February 2016 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

OMEGA Graxicon: The uniform and efficient coupling of laser light to cryogenic targets is critical to achieving stable high-pressure implosions on OMEGA. One of several approaches for the mitigation of cross-beam energy transfer on the OMEGA laser involves decreasing the energy near the edge of the spherical target as the radius shrinks during the implosion.[1,2] However, the drive uniformity early in time would be reduced if a smaller focal spot is maintained throughout the entire pulse. Focal-spot zooming between the low-intensity early time part of the pulse and the high-intensity main drive that follows would provide the necessary decrease in spot size at the optimum time. In addition, focal-spot zooming during the main pulse would provide greater energy coupling as the target is compressed in size. A novel optical device, referred to as a Graxicon, could provide two-state or continuous focal zooming on inertial confinement fusion targets.

The Graxicon consists of a grating axicon and a refractive axicon that are located on two consecutive optical surfaces. The first grating axicon diffracts the laser beam radially outward while the second axicon refracts the laser beam in the opposite direction. For the main wavelength of light, the deflections from the two axicons cancel and collimated light is propagated toward the distributed phase plate (DPP) and focused on target. Since diffractive dispersion is greater than refractive dispersion, the conical phases do not cancel for longer wavelengths of light, and a larger phase-converted spot is produced in the focal plane (Fig. 1). Time-dependent zooming is achieved by spectrally shifting the laser beam from longer wavelengths early in the pulse toward the main wavelength later in the pulse.

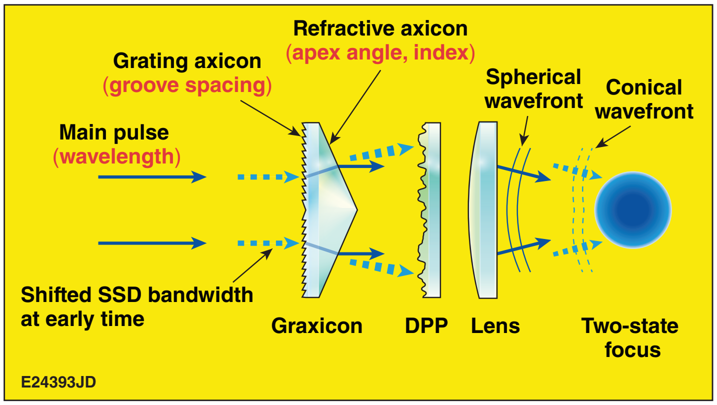

Figure 1. With a dispersion-corrected Graxicon located at the end of the laser, temporal wavelength shifting could be used to zoom the focal spot. A spectrally matched distributed phase plate (DPP) would be used to maintain the required focal-spot profile on target.

The Optics and Imaging Sciences Group has carried the Graxicon from concept to small-scale prototype. Four-inch-diam axicon prototypes were assembled within an interferometer to achieve conical phase matching [Fig. 2(a)]. The Graxicon was tested with a continuous-wave Ar laser to demonstrate its large zooming capability with broadband laser light. The two near-ultraviolet Ar lines were individually propagated through the Graxicon to the target plane without being phase converted by a DPP. The large ring focus (λ = 363.8 nm) in Fig. 2(b) was reduced to a fraction of a typical target diameter when the wavelength was decreased (λ = 351.1 nm). Zooming on the OMEGA Laser System using a Graxicon would require only a fraction of this test bandwidth to achieve a focal-spot ratio between 1.5 and 2.

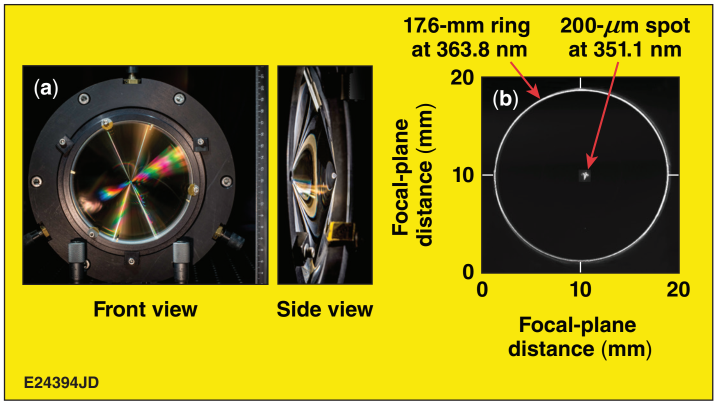

Figure 2. (a) A 4-in. prototype Graxicon was assembled and tested. (b) Radial displacement at the focal plane of ultraviolet lines of an Ar laser.

Omega Facility Operations Summary: The Omega Laser Facility conducted 211 target shots in February with an average experimental effectiveness (EE) of 96.9%. The OMEGA laser had 122 shots with an EE of 97.5% and OMEGA EP had 89 shots with an EE of 96.1%. LLE ICF experiments totaled 87 target shots and HED program experiments led by LANL, LLNL, and LLE accounted for 74 shots. The University of California, San Diego and University of Michigan NLUF experiments had 16 target shots and LBS experiments led by LLNL and LLE had 28 target shots. Six shots were taken for CEA-led experiments.

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1. D. H. Froula *et al*., Phys. Rev. Lett. **108**, 125003 (2012).
2. I. V. Igumenshchev *et al*., Phys. Plasmas **17**, 122708 (2010).