March 2003 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Cryogenic Target Characterization: At LLE, cryogenic targets are presently characterized using a shadowgraphic technique similar to the one originally used on OMEGA in 1988. This technique was further developed by LLNL. Recently, LLE and LLNL have collaborated on enhancing this technique using improved optical setups and analysis techniques. To improve the understanding of this technique, LLE obtained thick-walled CH targets from General Atomics to serve as surrogate cryo targets. The quality of the shadowgraphs is very high, rendering a multitude of rings that are produced by various rays through the target (Fig. 1). The "standard" intense ring pattern follows a ray path (b) (as indicated in red) with one total internal reflection from the inner surface. The same spot on the inner surface is also probed by the green rays (u). In fact, a number of rays suffer several internal bounces similar to the "u" rays; they all probe the inner surface from the inside and produce very sharp, closely spaced rings with a short focal depth. In addition, "d" rays form an intermediate, fairly strong ring and probe the apex of the outer surface. All of these rings have been uniquely identified using spherically symmetric numerical simulations. Most of the information regarding ice-layer thickness and its variations is obtained from the strongest ring formed by the "b" rays. The weaker inner rings, however, can yield important additional information relating to the ice–plastic shell interface—a process LLE is presently studying in real, layered cryogenic targets.

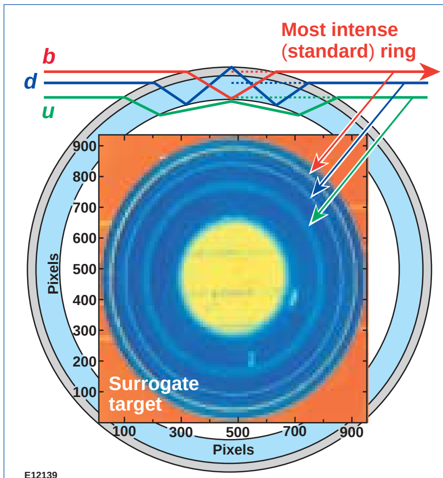

Figure 1. Shadowgraph image of a thick CH surrogate target revealing a number of rings. The ray diagram shows the ray paths that give rise to the main rings visible in the experimental image. These rings and their associated ray paths have been uniquely identified using numerical simulations.

Thomson Scattering from Plasmons near the Landau Cutoff: The two-plasmon-decay (TPD) instability is of concern to direct-drive fusion experiments because of its potential to generate energetic electrons that can preheat the core before peak compression. In an effort to better understand this instability, LLE has designed long-scale-length experiments that probe plasma-wave propagation near the Landau cutoff. As has been confirmed, plasma waves (plasmons) above this cutoff are heavily damped. The TPD plasmons were excited by 351-nm laser radiation at intensities ~10^{15} W/cm^2. Thomson scattering was used to identify and diagnose the TPD plasmons; one of OMEGA's 60 laser beams focused to ~2×10^{14} W/cm^2 was used as the probe beam. Upscattering of the Thomson-scattered light appears near the 3/2 harmonic of the incident light (Fig. 2). The Thomson-scattered signal is distinguished from the usual 3/2-harmonic emission by temporally overlapping the Thomson probe over only half of the interaction beam when a separate Thomson probe was used. The Thomson signal is typically five to ten times more intense then the usual 3/2-harmonic signal. The scattering geometry was arranged such that the interaction beam 47 could act as its own Thomson probe [self-scattering, Fig. 2(a)]. As such, it probed plasma waves with $k_{p,b}\lambda_{De}$ ~ 0.3, i.e., very close to the Landau cutoff for the blue TPD plasmons with wave number $k_{p,b}$ (λ_{De} = Debye length). With an additional Thomson probe [beam 56, Fig. 2(b)] the plasma was heated sufficiently to dampen the plasmons involved in self-scattering. The Thomson-scattered signal (TP56→) is clearly visible, albeit weakly, at the expected reduced red shift. After the end of the Thomson probe, the plasma cools off and the self-scattering signal from beam 47 reappears as $k_{p,b}\lambda_{De}$ decreases below the Landau cutoff. The strong blue-shifted signal in Fig. 2(b) is also due to Thomson scattering from near the Landau cutoff that involves another set of beams.

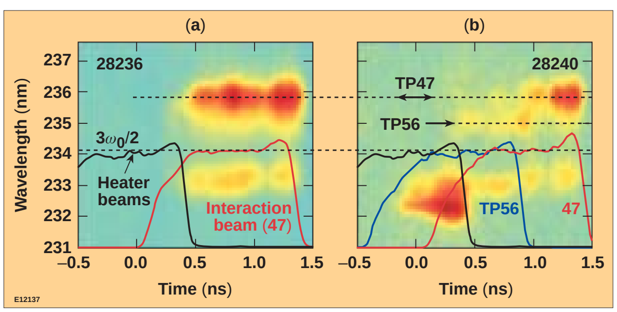

Figure 2. Thomson-scattering signal from TPD plasmons in (a) "self-scattering" geometry (TP47; beam 47 = interaction beam and Thomson probe), and (b) with beam 56 as Thomson probe (shot 28240). While beam 56 is on, the plasma is heated to the point where the self-scattering signal is suppressed by Landau damping while the Thomson-scattered signal for this probe is visible (TP56→).

OMEGA Operations Summary: A total of 90 target shots were taken on OMEGA in March for campaigns by LLE (55 shots) and LLNL (35 shots). The last week in March was a scheduled maintenance week. Tasks conducted during this week included the installation of a diode-pumped regenerative amplifier on the main driver and conversion of the facility vacuum system to accommodate the relocation of the roughing pumps.

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