Thomson-Scattering Advancements: Direct-drive inertial confinement fusion (ICF) requires laser beams to efficiently propagate through isothermally expanding plasmas, where their profiles are determined by the inverse bremsstrahlung absorption and heat transport. Laser–plasma interactions modify these plasma profiles by redirecting energy from the incident laser beams. This redirected energy typically lowers the electron temperatures and modifies the density profile further affecting the refraction of the incident laser light, modifying the absorption coefficients, and reducing the stimulated backscatter thresholds. Thomson scattering provides local measurements of the plasma conditions that are essential in validating hydrodynamic simulations used to design ICF experiments.

Recent advancements in the OMEGA ultraviolet (UV) Thomson-scattering diagnostic provide the ability to effectively collect, transport, and detect deep UV photons (~190 nm) (Ref. 1) allowing light scattered from electron plasma waves near densities of 2.5×10^{21} cm^{-3} to be measured. The near-diffraction–limited achromatic optical system delivers a well-defined 50-μm × 50-μm × 50-μm scattering volume, providing excellent rejection of the background plasma emission and allowing for simultaneous localized measurements of the ion-acoustic and electron plasma wave features. Previously refractive collection systems have restricted Thomson-scattering systems to wavelengths above 225 nm, limiting the ability to probe electron plasma waves at densities greater than ~2.5×10^{20} cm^{-3} (Ref. 2).

Figure 1 shows the temporally resolved electron and ion-acoustic features measured in the corona of a directly driven implosion at the three different scattering locations. When scattered from the plasma, the frequency of the incident probe beam was shifted by the frequency of the ion-acoustic waves (ion-acoustic features) and electron plasma waves (electron plasma feature) and to first-order these frequency shifts provide a measure of the electron temperature and density, respectively. The width of the electron feature is given by the Landau damping of the electron plasma waves and provides an independent measure of the electron temperature. In these CH plasmas, the solution to the kinetic dispersion relation gives slow and fast ion-acoustic modes[3,4] and the relative damping of these modes modifies the width of the scattering peaks and provides a measure of the ion temperature.[5]

A series of wavelength plateaus, each decreasing in wavelength, is observed in the electron plasma wave spectrum [Fig. 1 (top row)] and indicates increasing density plateaus propagating through the Thomson-scattering volume. During the main drive, a nearly constant density plasma is evident by the ~1-ns-long constant wavelength feature. This wavelength feature increases from 208 nm to 198 nm as the scattering volume is moved from 400 μm to 200 μm, corresponding to electron densites from 5×10^{20} cm^{-3} to 1.4×10^{21} cm^{-3}. At late times, the drive beams are turned off and the wavelength of this feature shifts back toward the probe wavelength indicating a rapidly decreasing density. The corresponding ion-acoustic spectra [Fig. 1 (bottom row)] show a nearly constant separation between the features and width during the drive indicating a constant electron and ion temperature.

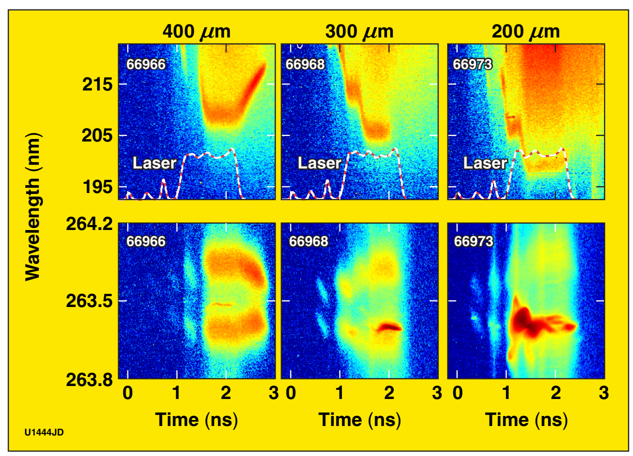

Figure 1. Shows both the electron plasma wave (top) and ion-acoustic wave (bottom) scattering features simultaneously collected from the same scattering volume located at three locations (400 μm, 300 μm, and 200 μm from the initial target radius) within the coronal plasma of a directly driven implosion. The triple-picket pulse shape used to drive the implosion is shown as a timing reference (insert). The implosion was driven at an intensity of 8×10^{14} W/cm^2.

Omega Facility Operations Summary: The Omega Laser Facility conducted 132 target shots in July (87 shots on the OMEGA Laser System and 45 shots on OMEGA EP Laser System). The experimental effectiveness averaged 97.7% (99.4% on OMEGA and 94.4% on OMEGA EP). The NIC campaign accounted for 42 target shots, and the HED, NLUF, and LBS programs accounted for 50, 23, and 15 target shots, respectively.

(1) J. Katz *et al*., Rev. Sci. Instrum. **83**, 10E349 (2012); (2) J. S. Ross *et al*., J. Inst. **6**, P08004 (2011); (3) D. H. Froula *et al*., Phys. Plasmas **13**, 052704 (2006); (4) E. A. Williams *et al*., Phys. Plasmas **2**, 129 (1995); (5) S. H. Glenzer *et al*., Phys. Rev. Lett. **77**, 1496 (1996).