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Profile Measurements of Temperature, Density and Velocity in High Energy Density Plasmas with High-Resolution X-ray Spectroscopy[1]
BRIAN KRAUS, Princeton University, LAN GAO, K. W. HILL, M. BITTER, W. FOX, P. C. EFTHIMION, Princeton Plasma Physics Laboratory, R. C. MANCINI, University of Nevada Reno, A. MOREAU, R. HOLLINGER, SHOUJUN WANG, HUANYU SONG, J. J. ROCCA, Colorado State University — Physics phenomena not formerly accessible in high-energy-density plasmas have been revealed by measured x-ray spectra with high resolving power (E/dE $\sim 10^4$) at the extreme-contrast ALEPH 400 nm laser using precision layered targets. Fine structure x-ray emission from laser-heated H-, He-, and Li-like Ti has been recorded by a trio of x-ray crystal spectrometers. The set of targets, with thin ($0.1-1$ μm) Ti tracer layers sandwiched inside Al foils to provide spatial resolution, were heated by high-intensity (10^{21} W/cm^2) light with high temporal contrast (10^{12} at 25 ps). The Ti Heβ lineshape appears strongly double-peaked, with peak separation compared to Stark lineshape code MERL to constrain the ion temperature and electron density. Furthermore, the x-ray emission of Ti Lyα and Heα resonance lines reveal large Doppler shifts due to ion ablation and target expansion; these shifts were viewed from two sides so that directional velocity distribution profiles can be inferred. These temperature, density, and velocity profiles provide information on heat transport of these expanding plasmas and thus establish a benchmark for hydrodynamic models of the plasma evolution.

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