Dynamic X-ray Thomson scattering from high-energy-density plasmas using an ultra-bright X-ray laser

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Abstracts: *Recent x-ray scattering experiments performed at the MEC end-station of the LCLS, have demonstrated novel plasma measurements of the electron temperature, pressure, and density by simultaneous high-resolution angularly and spectrally resolved x-ray scattering from shock-compressed materials in the warm dense regime. Such measurements provide the structural properties relating the microscopic quantities in terms of thermodynamic properties using first-principles calculations.*

Our new high-energy-density science program at SLAC is aimed to take advantage of x-ray pulses with the highest peak brightness available today. This capability allows us to measure plasmons and to visualize the density and pressure evolution across melt lines by resolving correlations at distances comparable to atomic scales. We will show how LCLS data test our theoretical models of compressed matter at pressures exceeding 5 Mbar and will discuss future plans for the study of warm dense matter. These studies have led us on a path where we create conditions with increasing temperatures and pressures to explore the high-energy density phase space. Specifically, we have begun experiments on hot and dense hydrogen plasmas producing energetic proton beams that find applications in fusion research and astrophysical phenomena. For our experiments with the 25 TW short pulse laser we apply repetition rates and pulse widths with a good match to the LCLS x-ray beam capabilities allowing pump-probe experiments with ultrahigh temporal resolution with very high data throughput with shot rates of up to 5 Hz. In this talk we will discuss our recent measurements that have resolved the ultrafast structural response of hydrogen to intense heating and the comparison with density functional theory modeling.

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