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High-Energy Density science with an ultra-bright x-ray laser[1]

SIEGFRIED GLENZER, SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025

This talk will review recent progress in high-energy density physics using the world's brightest x-ray source, the Linac Coherent Light Source, SLAC's free electron x-ray laser. These experiments investigate laser-driven matter in extreme conditions where powerful x-ray scattering and imaging techniques have been applied to resolve ionic interactions at atomic (Ångstrom) scale lengths and to visualize the formation of dense plasma states. Major research areas include dynamic compression experiments of solid targets to determine structural properties and to discover and characterize phase transitions at mega-bar pressures. A second area studies extreme fields produced by high-intensity radiation where fundamental questions of laboratory plasmas can be related to cosmological phenomena. Each of these areas takes advantage of the unique properties of the LCLS x-ray beam. They include small foci for achieving high intensity or high spatial resolution, high photon flux for dynamic structure factor measurements in single shots, and high spectral bandwidth to resolve plasmon (Langmuir) waves or ion acoustic waves in dense plasmas. We will further describe new developments of ultrafast pump-probe technique at high repetition rates. These include studies on dense cryogenic hydrogen that have begun providing fundamental insights into the physical properties of matter in extreme conditions that are important for astrophysics, fusion experiments and generation of radiation sources.

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