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Creating Extreme Material Properties with High-Energy Laser Systems

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Laboratory for Laser Energetics, University of Rochester, 250 E. River Rd, Rochester, NY 14623 High-energy laser systems create extreme states of matter by coupling their energy into a target via ablation of the outer layers. In planar experiments on the OMEGA laser system, single-shock pressures can exceed 10 Mbar. In spherical geometry, the compressed target pressures can be significantly higher than 1 Gbar. These pressures will be increased by one or two orders of magnitude on the 1.8-MJ_{UV} National Ignition Facility, under construction at LLNL. The inherent flexibility of multibeam laser systems allows many techniques to be applied to studying the properties of materials under extreme conditions. Recent experiments have used Extended X-ray Absorption Fine Structure to observe shock-induced phase transformations in Fe on the ns time scale. Techniques are being used and/or developed to measure the equation of state of compressed materials, including solids, foams, and liquid D_2, both on and off the Hugoniot. The coupling of high-energy petawatt (HEPW) lasers to high-energy laser systems will greatly extend the accessible range of material conditions. HEPW lasers produce extremely intense beams of electrons and protons that can be coupled with high-energy compression to access a large region of temperature and density space, for example, by heating a compressed target. These beams, along with the extremely bright x-ray emission, provide new diagnostic opportunities. This presentation will highlight some of the recent advances and future opportunities in creating and measuring extreme materials properties. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the NY State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.