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Theory of Ultrafast Plastic Deformation of Metals at the LCLS¹ ROBERT RUDD, HYE-SOOK PARK, CHRIS WEHRENBERG, BRUCE REM-INGTON, Lawrence Livermore National Lab — High-rate plastic deformation is the subject of increasing experimental activity. As high energy laser platforms such as those at the National Ignition Facility (NIF) are pushing the horizons plasticity at extremely high pressures and rates in shock and non-shock ramp-compression waves, fourth generation light sources like the Linac Coherent Light Source (LCLS) are opening the door to dynamic plasticity experiments with extremely high temporal resolution. Here we describe the theory of high-rate deformation of metals and how high energy lasers can be, and are, used to study the mechanical strength of materials under extreme conditions. Specifically, we describe predictions of LLNL's multiscale strength model and molecular dynamics (MD) simulations that can be directly, validated or refuted at these new facilities. This work focuses on the bcc metal tantalum at pressures up to 2 Mbar, but other metals such as vanadium and titanium will be considered briefly. In situ x-ray diffraction and scattering experiments provide a direct diagnostic of the lattice-level response of the material that can be compared to the MD and multiscale modeling predictions including deformation modes and plastic relaxation times.

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