DPP11-2011-000325

Abstract for an Invited Paper
for the DPP11 Meeting of
the American Physical Society

The Creation and Diagnosis of Hot Solid-Density Plasmas with an X-ray Free-Electron Laser

SAM VINKO, Department of Physics, Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, UK

We report on the first experimental investigation of the detailed interaction process of an intense short-pulse X-ray beam with solid density matter, conducted on the Linac Coherent Light Source X-ray laser at SLAC National Accelerator Laboratory. In the experiment, we have focused the X-ray beam to micron-size spots on a thin aluminum foil, thereby heating it to temperatures up to 200 eV. This is achieved on the time scale of the excitation pulse, of order 80 fs FWHM, far quicker than the time necessary for electron-ion coupling and hydrodynamic expansion, so that a hot plasma is created at solid densities. We have studied this system by X-ray K-alpha spectroscopy for a range of excitation photon energies above the cold aluminum K-edge. Detailed simulations of the interaction process were conducted with the radiative-collisional code SCFLY, illustrating a good overall agreement with the experimental spectra, and, importantly, also providing insight into the evolution of the charge state distribution within the sample, the electron density and temperature, and the ionization potential depression. In particular, we note that the spectra observed in emission and the fundamental properties of the system are not trivially related, but are rather complicated by the intense FEL pulse, which acts both as a heating source as well as a low-bandwidth probe. We discuss our experimental results in light of these observations and their implications for the study of X-ray laser-generated dense plasmas.