Probing solid density plasmas generated by X-ray Free Electron lasers with an ultrashort High Harmonic source

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X-ray Free Electron lasers interacting with solids generate solid density plasmas in the warm dense matter (WDM) state. By quasi-instantaneously heating the core of the solid, a homogeneous plasma slab is created, opening an opportunity for benchmark measurements of opacity and refraction of WDM. To probe solid density, XUV wavelengths are required. In this experiment, the LCLS X-ray laser was focused on thin aluminum foils at intensities of 10^{16}W/cm^2. High Harmonic (HH) radiation from Ar centered at 39 eV probed the Al plasma. The evolution of the plasma opacity, coupled to a refraction measurement, revealed the importance of heating rates for WDM. XUV transmission and the plasma self-emission (K-shell and soft X-ray bremsstrahlung radiation) are compared to models supporting the warm dense aluminum's state. While classical plasma opacity estimates fail to reproduce the measured transmission, Quantum Molecular Dynamic and Random Phase Approximation models better reproduce the measured spectra.