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10.39 Measurement of Ion Acoustic Modes in Warm Dense Matter at the LCLS

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Warm dense Matter (WDM), intermediate between solids and plasmas, exhibits properties common to both. Due to its complexity, it is vital to directly measure the dynamic structure factor, providing information on electron-electron and ion-ion coupling. The high frequency plasmons, with an energy transfer of˜1-10 eV, have been successfully investigated using X-ray spectroscopy at large laser facilities. However, the low frequency ion acoustic modes, providing vital information regarding viscosity and thermal conductivity, have an energy transfer of just 0.1-1 eV, requiring diagnostics with a much smaller bandwidth and larger photon number than that achievable at large laser facilities. The advent of hard X-ray FELs, such as LCLS at SLAC has allowed unprecedented access to investigating the ion-ion structure factor. Here, we present a setup at the Matter at Extreme Conditions endstation used to measure ion acoustic modes in WDM. We combine the extremely bright X-ray source provided by LCLS with a four-pass single crystal monochromator, and diced Si crystal analysers to perform inelastic X-ray scattering measurements with a resolution of 50 meV. We demonstrate the measurement of phonons in diamond, and show this setup may be extended to studying materials in the WDM regime.

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