High resolution measurement of the momentum-dependent plasmonic excitations of 1 Mbar matter

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The modelling of astrophysical objects such as the interiors of giant planets, low mass stars and brown dwarfs is heavily reliant on the understanding of matter at temperatures of a few eV and pressures around 1 Mbar. The creation and diagnosis of these plasmas is challenging requiring controlled laser shock compression in order to keep the temperature low and simultaneous probing through inelastic X-ray scattering. Seeded operation at the Linac Coherent Light Source (LCLS) [1] gives us access to ultrafast, bright, highly monochromatic X-ray probes allowing the determination of highly resolved dynamic structure factor data [2]. We present here repeatable measurements of the plasmon dispersion in Aluminium both at ambient conditions and at compressed conditions around 1 Mbar pressure, and make estimates of the pressure, density and temperature using X-ray diffraction and optical VISAR measurements. We compare the plasmon dispersion with that expected from density-functional-theory molecular-dynamics calculations and explore the validity of various models at temperatures below 1 eV. Finally, we look forward to future measurements at the European XFEL's HED instrument.

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