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Observations of strong ion-ion correlations in dense plasmas

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The strong ion-ion correlation peak characteristic of warm dense matter (WDM) plasmas has recently been observed for the first time using simultaneous angularly, temporally, and spectrally resolved x-ray scattering measurements in laser-driven shock-compressed aluminum. High-energy (17.9 keV) laser-produced x-ray line emission has been employed to probe aluminum compressed to a density of greater than 8 g/cc. These experiments show a well-pronounced peak in the static structure factor at a wave number of k = 4 A^{-1}. The measurements of the magnitude and position of this correlation peak are precise enough to test different theoretical models for the ion structure and show that only models taking the complex interaction in WDM into account agree with the data. These studies have demonstrated a new highly accurate diagnostic technique to directly measure the state of compression and the ion-ion correlations. This new method is presently being applied in numerous experiments to characterize the physical properties of dense plasmas. In this talk, we will discuss the first demonstration of this novel technique, present applications to characterize shock conditions in solids and liquid, and innovative ideas for measuring new high-pressure material properties such as electrides.