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Probing the dynamic structure of warm dense matter

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Materials under extreme compression, as the one achieved by direct laser illumination, exhibit almost-equal thermal and Coulomb energies and structural properties that are in between those of ideal gases and solids. Their understanding is critical for the calculation of the equation-of-state of the interior of giant planets as well as for inertial confinement fusion research. In the recent years x-ray scattering has emerged as a powerful technique to accurately measure the microscopic properties (electron temperature and ionization state) of warm and dense matter states. At the same time it allows to extract the correlation and the dynamics of a semi-degenerate and strongly coupled systems. In this work, we will describe the details of the scattering models with a few examples drawn from experiments conducted in low-Z materials (Li, B and CH) using high power lasers. In addition to x-ray scattering, the shock properties have been monitored with a dual color VISAR, shock break-out, as well as with a XUV flat-field spectrometer, in order to provide independent cross validation of the diagnostic method. Further progress of the x-ray scattering techniques will be discussed, with particular attention on how to extend these methods to new 4th generation light sources to achieve both sub-picosecond and micron-scale resolution to investigate non-equilibrium and transient systems.