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Unraveling warm dense matter: from theory to experiment

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The rigorous description of warm dense matter (WDM)—an extreme state that is characterized by high densities, temperatures, and pressures—is of high importance for integrated radiation hydrodynamics simulations of inertial confinement fusion applications, in particular during the initial stage of the compression path. In addition, WDM conditions abound in a host of astro-physical objects such as giant planet interiors and white dwarf atmospheres. In the laboratory, WDM can be created using different techniques, but accurately diagnosing even basic parameters such as the density or temperature is difficult and usually relies on various model assumptions and approximations [1]. Very recently, we have shown that it is possible to extract a wealth of information such as the temperature [2] or degree of non-equilibrium [3] directly from x-ray Thomson scattering (XRTS) measurements without the need for any models or simulations. The combination of this new paradigm with highly accurate path integral Monte Carlo (PIMC) simulations [4] allows us to rigorously diagnose an experiment with spherically compressed beryllium carried out at the National Ignition Facility (NIF) [5], leading to a substantially lower estimate for the mass density ($\rho = 22 \pm 2$ g/cc) compared to the Chihara model used in the original analysis ($\rho = 34 \pm 4$ g/cc). Our work has important implications for radiation hydrodynamics simulations of implosion dynamics and equation-of-state measurements.

References

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Primary author: DORNHEIM, Tobias (Center for Advanced Systems Understanding | Helmholtz-Zentrum Dresden-Rossendorf)

Presenter: DORNHEIM, Tobias (Center for Advanced Systems Understanding | Helmholtz-Zentrum Dresden-Rossendorf)