Overlapping Experimental and Theoretical Challenges in Warm Dense Matter

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Laboratory-based studies of warm dense matter (WDM) present unique scientific opportunities under conditions relevant for planetary and stellar physics and the early stages of compression in inertial confinement fusion. However, there is growing evidence that these conditions, *i.e.*, solid-like or elevated density with partial ionization, should also be viewed as a next-stage of evolution of the thermodynamic parameter space available to the condensed phase community. As a case in point, we have recently demonstrated that a central tenet of the theory of the electronic structure of condensed matter, the orthogonalization of valence- and core-electron wavefunctions, must be included in any reliable calculation of the momentum distribution function $n(p)$ and dynamic structure factor $S(q,\omega)$ for WDM.[1] This observation runs contrary to the common belief that the valence-core interaction becomes progressively less important as plasma density increases. It also has important practical consequences: $S(\vec{q},\omega)$, measured by nonresonant inelastic x-ray scattering, is the key physical observable used as the basis for thermometry in WDM studies of light elements. While presenting the theoretical methods used and the consequences of this work for experiment, we will emphasize the causality dilemma residing in the overlap of theory and experiment: which comes first, a demonstrably reliable WDM thermometry or a demonstrably reliable calculation of WDM electronic structure or equation of state?

[1] B.A. Mattern, G.T. Seidler, J.J. Kas, “Condensed phase effects on the electronic momentum distribution in the warm dense matter regime,” arXiv:1308.2990v2, submitted PRL (2013).