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A new approach to understanding Warm Dense Matter

By

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The physical state of matter at density $\sim $ 1 g/cm^{3} and temperature $\sim $ 1 eV - called Warm Dense Matter (WDM) -- has been a misty island in the phase plane describing the structure of matter. Logical approaches (starting from hot solids, dense chemically-reacting fluids, low-temperature plasmas or release from shock-compressed solids) reach a barrier in the WDM range beyond which the theories do not converge and fail to describe the strongly interacting mix of atoms, molecules, ions and semi-free electrons. This talk will describe the most challenging scientific questions for WDM and will sketch a new approach, based on a high-density version of the Saha (chemical-equilibrium) method.\footnote{This work was done in collaboration with Dr. M. P. Desjarlais of the Sandia National Laboratories, Albuquerque, NM.} The advantage of the new method is that it incorporates a great deal of existing experimental data in a coherent thermodynamic structure. The method can be tested against quantum molecular dynamics, which has provided surprising ideas about the importance of dimers (weakly bound molecules) and the metal-insulator transition in WDM. On the experimental side, good results require rapid heating to produce the desired conditions, along with rapid diagnostics to acquire data, before the sample has time to disassemble. While electrical heating is relatively slow and laser heating is inherently non-uniform, new heating technologies such as intense pulsed ion-beam and x-ray deposition can be faster and more homogeneous. Recent progress on developing experiments using these methods will be presented.