Structures and transport properties of warm dense hydrogen

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The structural, thermodynamic and transport properties of warm dense matter (WDM) are crucial to the fields of astrophysical physics, planet science, as well as inertial confinement fusion. WDM refers to the states of matter in a regime of temperature and density between cold condensed matter and hot ideal plasmas, where the density is from near up to 10 times solid density and the temperature is between 0.1 and 100 eV. In the WDM regime, matter exhibits moderately or strongly coupled, partially degenerate. Therefore, the methods which used to deal with condensed matter and isolated atom should be validated for WDM properly. It is therefore a big challenge to understand WDM within a unified theoretical description with reliable accuracy. Here we study the liquid-liquid phase transition of dense hydrogen with first principles molecular dynamics including van der Waals interactions and non-local interactions. The results are in good agreement with the quantum monte carlo simulations and we give the dynamical properties such as diffusion coefficients. Also, by using electron force field molecular dynamics, we study the dynamics of electron-ion energy exchange in warm dense hydrogen, giving the temperature relaxation time after strong laser deposition. The results show that interplay between quantum electrons and coupled ions are crucial for the scattering processes, which result in much lower relaxation rate comparing with the results from traditional kinetic models and classical molecular dynamics.