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Quantum Hydrodynamics and Warm Dense Matter

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The experimental and computational investigation of both equilibrium and non-equilibrium strongly coupled systems with partially or fully degenerate electrons is an intellectually stimulating and scientifically challenging problem. Warm dense matter (WDM) is of particular interest since it exists in the lower-temperature portion of the high energy density regime, under conditions where the assumptions of both condensed-matter theory and ideal-plasma theory break down, and where quantum mechanics, particle correlations, and electric forces are all important. [FESAC 2009]. Interiors of giant planets, brown dwarfs, and neutron star envelopes are all examples of WDM. A wide variety of theoretical methods have been developed and are in routine use for studying warm dense matter. This includes density functional theory, time-dependent density functional theory, and quantum kinetic theory. Recently, there has been a resurgence in interest in using a simpler approach to investigating WDM based on quantum hydrodynamics. Quantum Hydrodynamics (QHD) has a long and interesting history, dating back to the first developments by Madelung and Bohm. In this talk, we discuss the historical and recent developments in QHD, including its advantages and limitations. We discuss recent numerical approaches using QHD, including the work of Larder et al. based on Bohmian trajectories and the work of D. Michta who has developed a hybrid QHD-molecular dynamics code with an application to stopping power in WDM.