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Michigan Institute for Plasma Science and Engineering

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Quantum Hydrodynamics and Rayleigh-Taylor Instability

Matter at extreme pressures, temperatures, and densities characterizes a wide variety of natural and man-made phenomena, including interiors of Jovian size planets, hypervelocity meteor impacts, the burning core of stars, thermonuclear burning inertial confinement fusion capsules. Matter at these conditions defines the exciting and challenging field of High Energy Density Physics (HEDP). Besides vast experimental resources, there exists a rich set of computational tools that model the micro to macro regimes of HEDP. Recently, there has been a resurgence in interest in using a "simpler" approach to investigating HEDP 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 pitfalls, as applied to quantum many-body systems relevant to HEDP regimes. We will present three different approaches to deriving the QHD equations-Madelung, Bloch, and Wigner and discuss their pros and cons. Finally, the role that Rayleigh-Taylor hydrodynamic instabilities play is discussed within the QHD formalism.

About the Speaker: Frank Graziani received a BS in physics from Santa Clara U., and a PhD in physics from UCLA. He was a postdoctoral fellow at U. Colorado and U. Minnesota working in cosmology and particle physics; and worked with NASA on exoplanet dynamics and star formation. Dr. Graziani joined Lawrence Livermore National Lab. in 1989 where he worked in radiation transport and plasma physics. He has held many leadership positions at LLNL, including group leader, V&V Leader, PI for LDRD-Strategic Initiatives, lead for the National Boost Initiative and Assoc. Division Leader for computational physics. He now directs the High Energy Density Sciences Center. He has won four DOE Defense Program Awards of Excellence, the LLNL Director's S&T Award and is a Distinguished Member of the Technical Staff. His research interests include the micro-physics of dense plasmas and HED education. Dr. Graziani is editor of two books on computational methods and a book on warm dense matter physics.