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Physics of Light Dense Matter: Quantum and Classical Effects

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Restricting the volume of material through application of pressure, changes the dominance of interactions within the material and exposes unnatural states of matter not found in our predominantly adiabatic universe. These new basic interactions include inner electron core chemistry, interstitial electron localizations, quantum criticality and quantum ground states. Such interactions do not play a significant role in the elegant organization of the periodic table at ambient pressure, however they play a role in a denser periodic table which to date remains mostly unexplored. One of the most exotic phenomena in condensed matter is the phase transitions purely driven by quantum effects. While quantum fluctuations in electronic states are always relevant, it is also possible to observe quantum effects in lattice of very light elements. At ambient conditions, the lightest metal of the periodic system is lithium. Similar to hydrogen and helium even at zero temperature lattice of lithium remains far from static. However, while the fascinating quantum nature of condensed helium is suppressed at high densities, due to its metallic nature, lithium is expected to adapt more quantum solid behavior under compression. In this talk I will review some of the major goals of research in high pressure physics and discuss the physics of ultra-light materials under extreme pressures. I will also present some of our studies on quantum contributions to the structural phase transitions of lithium at low temperature, the structure of its low temperature structure and will present our results on the resolving the long lasting mystery of lithium ground state.