Matter at extreme energy density: Exotic solids and core electron chemistry

Abstract: A new generation of extreme matter experiments is underway, recreating conditions that exist deep inside planets and stars, and creating materials not previously imagined. Exquisite pressure control can now produce highly degenerate conditions with atoms brought together closer than the Bohr radius, where a new regime of chemical bonding is anticipated, engaging core as well as valence electrons. I will show the first structural and mechanical data for solids at TPa (1 TPa = 10 million atmospheres) conditions and describe how these data provide compositional insight for terrestrial planets and new constraints for quantum-many-body theory. New melt curve data for several silicates, oxides and iron show comparable melting temperatures near TPa pressures, suggesting molten silicates might coexist with liquid iron alloys in large rocky planets. At higher temperatures, fluid phase data for helium-hydrogen mixtures, silicates, oxides, and carbon reveal new chemically complex phases well into the multi-TPa regime. I hope to paint a picture that shows how this new extreme matter frontier, over the next decade, will change the way we think about planets, (platforms for life throughout the universe), new materials on Earth, and how matter approaches equilibrium.

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Host: Professor Bruce Kusse, 206 Clark Hall, BRK2@cornell.edu, 5-6252