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Exotic Behavior of Materials at Ultra-High Densities

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New compression and diagnostic techniques reveal that matter at ultra-high densities can exhibit quite exotic behavior. For example, shock compressed He, precompressed in a diamond anvil cell, shows He transforms to a metal at $\sim$2.5 g/cc. Single and multiple shock compression data for diamond shows the melting temperature is constant from 0.6 TPa to 2 TPa. Ramp wave compression now allows us to explore solid-state properties into the TPa regime and reveals that at low temperatures the diamond phase of carbon is stable and strong to 0.8 TPa. By varying the ramp compression time we can explore the kinetics of phase transitions and strength. For example, above a material dependent critical strain rate for Bi or Fe, the pressure required to cross a given phase boundary increases logarithmically with strain rate. Over the next few years, these techniques will allow us to explore the nature of solids to several TPa, complex chemistry to 100 TPa (1 Gbar), and the nature of helium and hydrogen at interatomic spacings comparable to their DeBroglie wavelength.

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