Material Behavior in Exoplanet Interiors

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What are exoplanet interiors made of? The answer matters because interiors comprise nearly all the planetary mass and therefore shape our ideas about formation, as well as controlling long-term evolution, the generation of planetary magnetic fields and volcanism, and in the case of super-Earths the generation of surface environments, and the prospects for habitability. We examine possible connections between the interior and atmospheric composition, focusing on processes of differentiation, buoyant segregation, core erosion, and de-gassing. These processes highlight the importance of learning more about material behavior in the largely unexplored region of pressure-temperature space typical of most exoplanetary interiors discovered so far. We discuss examples of progress in these areas, focusing on ab initio quantum mechanical simulations of the phase diagrams of helium and iron, vaporization and electrical conductivity of silicates, and chemical reaction between hydrogen and iron, as well as advances in thermodynamic modeling of very high pressure multi-component phase diagrams. We will explore implications for the luminosity of giant planets, the generation of magnetic fields in super-Earths, and the nature of mini-Neptunes.