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# Suppression of Core Formation in Hydrogen-Bearing Planetary Interiors and Its Impact on Planetary Radii

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Planetary interiors are commonly modeled as chemically differentiated structures composed of a metallic core and a silicate mantle; however, sub-Neptunes, which dominate the exoplanet census, reach interior pressures and temperatures far exceeding those of terrestrial planets, raising the question of whether this paradigm remains valid under such extreme conditions. Their internal structures are nevertheless commonly treated as scaled-up terrestrial planets, consisting of a dense iron core, a silicate mantle, and a hydrogen-rich envelope. In this work, we test whether this layered picture remains physically valid under the extreme conditions expected in sub-Neptune interiors by using density functional theory molecular dynamics (DFT-MD) simulations and thermodynamic mixing models to examine how silicates, iron, and hydrogen interact deep inside these planets.

We find that sub-Neptunes containing hydrogen at the weight-percent level lack a distinct metal core once interior pressures exceed ~20 GPa and temperatures reach ~5000 K. Under these conditions, a separate metal phase is not thermodynamically stable and can only exist at lower pressures and temperatures, confining any compositional layering to relatively shallow regions of the planet. As a result, the deep interiors of typical sub-Neptunes are effectively core-less, consisting of supercritical mixtures of silicates, iron, and hydrogen rather than classically differentiated structures.

Incorporating this behavior into coupled interior–atmosphere structure models suppresses the formation of a dense, Earth-like iron core in hydrogen-bearing interiors, leading to lower bulk densities and larger planetary radii. For a representative 6 Earth-mass sub-Neptune containing 2 wt% hydrogen, we find that a fully mixed interior produces a transit radius roughly 10% larger than an otherwise identical planet with a discrete iron core, corresponding to density differences at the tens-of-percent level. These results imply that interior phase behavior, including the ability of hydrogen to participate chemically in the deep interior, fundamentally controls the internal structure of sub-Neptunes, with observable mass–radius trends emerging as a direct consequence.