Density deficit of Earth's inner core revealed by a multi-megabar rhenium pressure scale

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Precise information about the composition of the Earth's core is critical to understand planetary evolution and for discussing geodynamic behaviors, such as the core-mantle boundary heat flow. Our knowledge on the Earth's core is based on comparison of laboratory measurements with seismological observations, informed by meteorite composition, and indications of the Earth's core temperature. One of the most interesting results of such work has been the suggestion that Earth's inner core must contain light elements because the density of the core, as determined from seismological measurements, is lower than the density of pure iron, its main constituent, as determined from laboratory measurements and/or theoretical work: the density deficit of the inner core has been considered ~ 4%. However, this conclusion relies critically on an accurate pressure scale to relate laboratory generated pressures to geological pressures. Establishing such a scale has been the subject of intensive research but still involves significant extrapolation and approximations, especially at higher pressures of the Earth's core. Further, a pressure scale to the multi-megabar pressures is indispensable for discussing super-Earth planets. We report here the first primary pressure scale extending to the multi-megabar pressures of Earth's core by measuring acoustic phonon velocities using inelastic X-ray scattering from a rhenium sample in a diamond anvil cell. Our new pressure scale agrees with previous primary scales at lower pressures and also shock compression experiments, but it is lower than previous secondary and theoretical scales at Earth's core pressures: previous scales have overestimated laboratory pressures by at least 20% at 230GPa. Our new scale suggests the density deficit of the inner core is ~9%, doubling the light-element content of the inner core.

Keywords: primary pressure scale, high pressure, Earth's core, density deficit, inelastic x-ray scattering.

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