The 528th Geodynamics Seminar

First-principles prediction of iron viscosity at conditions of the Earth's center suggests small inner core translation and superrotation

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The Earth's inner core is primarily composed of iron. Its rheological properties influence both the Earth's rotation and deformation of the inner core which is a potential source of the observed seismic anisotropy. However, the rheology of the inner core is poorly understood. Here, we propose a mineral physics approach based on the density functional theory to infer the viscosity of hexagonal close packed (hcp) iron at the inner core pressure and temperature. As plastic deformation is rate-limited by atomic diffusion under the extreme conditions of the Earth's center, we quantify self-diffusion in iron non-empirically. The results are applied to model steady-state creep of hcp iron. We show that dislocation creep is a key mechanism driving deformation of the inner core. The associated viscosity agrees well with the estimates from geophysical observations supporting that the inner core is significantly less viscous than the Earth's mantle. Such low viscosity rules out inner core translation, with melting on one hemisphere and solidification on the other, but is expected to maintain the gravitational coupling between the Earth's mantle and inner core.

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