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Coupled dynamics of the Earth's inner core and F-layer

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The hemispherical asymmetry seen in the seismological properties of the inner core has recently been interpreted as resulting form a high-viscosity mode of inner core thermal convection, consisting in a translation of the inner core with melting on one hemisphere and solidification on the other. The large melt production associated with inner core translation may be at the origin of the F-layer, an anomalous, stably stratified layer at the base of the outer core, with melting of the inner core providing the dense iron-rich melt necessary for the formation of the layer. Being a thermal convection mode, a prerequisite for the existence of convective translation is that a superadiabatic temperature profile is maintained within the inner core, which depends on a competition between extraction of the inner core internal heat by conduction and cooling at the ICB. While the low thermal conductivity value proposed by Stacey & Loper (2007) makes inner core thermal convection likely, the much higher estimate recently put forward by Sha & Cohen (2011), de Koker et al. (2012) and Pozzo et al. (2012) makes inner core thermal convection almost impossible. We argue however that the formation of the F-layer has a positive feedback on inner core convection which could overcome the stabilizing effect of a large thermal conductivity. The formation of an iron-rich layer above the ICB implies that the inner core crystallizes from a source which is increasingly depleted in light elements. This produces an unstable compositional profile in the inner core that intensify inner core convection. The reciprocal coupling between the inner core and the F-layer creates a positive feedback loop which can make the system (inner core + F-layer) unstable. The mechanism releases more gravitational energy than purely radial inner core growth with no melting, and is therefore energetically favored.