SCALING THE DIFFERENTIAL ROTATION OF THE EARTH'S INNER CORE

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A recent dynamical model for flow in the Earth's outer core has provided a possible explanation for the correlation between the seismic structures of the upper inner core and lower mantle. This model requires the inner core to have remained nearly aligned with the lower mantle over the last hundred million years. This is apparently conflicting with the ongoing seismic inferences of inner core differential rotation at rates of about 0.1 degrees per year. Gravitational coupling between the inner core and the mantle has been invoked to resolve this issue, but recent estimates of the strength of this coupling suggest that it might be too weak to slow down the inner core to the required drift rate. In this presentation, a parameter space study of numerical dynamos is performed with an inner core rotating subject to viscous, magnetic and gravitational torques. The accessible parameter space is rather narrow and computationally expensive, due to the need to obtain nominal magnetic torques which largely overcome the nominal viscous torques. The simulations confirm that gravitational coupling brakes the inner core, i.e. that an upper bound for differential rotation is obtained when the gravitational coupling is absent. In this configuration, it is shown that the viscous torque is the driving torque, even though it is not the nominally strongest torque. A theoretical analysis reveals that the ratio of steady differential inner core rotation to steady outer core rotation decreases with the square root of the Ekman number, reflecting the decreasing efficiency of viscous driving as this number decreases. However, the typical fluctuations of differential rotation about the steady value remain of the order of the typical outer core rotation, due to efficient coupling by strong transient magnetic torques. An extrapolation of these results to Earth's core conditions suggests that the steady inner core rotation is weak enough for the inner core and mantle to remain aligned over hundred million years, while the fluctuations provide an interpretation for the seismically observed differential rotation.

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