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Using Mercury's physical libration in longitude to constrain its interior geometry

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As Mercury undergoes its 88 day period physical libration, the axes of minimum moment of inertia of the mantle and solid core (IC) become misaligned, leading to a gravitational torque between the two. The torque initiates a free axial oscillation between the IC and mantle. In the presence of a large IC-mantle gravitational torque, it is possible to achieve free-mode periods that approach 88 days, and perturbations in the rotation rate become a superposition of libration and free-mode periodicities. The dependence of the free-mode period on interior structure enables us to use Mercury's rotational response to constrain its interior. We represent Mercury as a sphere consisting of three concentric layers, including a solid mantle and fluid and solid cores. For a range of interior geometries and density structures, we model the time dependent perturbations in Mercury's rotation rate by numerically solving the governing set of coupled differential equations. The simulation results are compared to rotation rate data measured using radar speckle patterns. For models where the free-oscillation interferes with the libration signature, we are able to provide a marginally better fit between prediction and data than models which exhibit the libration signature alone. Preliminary results also suggest that there is a critical IC radius, above which the misfit is large enough for the interior geometry to be considered an improbable representation of Mercury's current state.