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Modeling Subsurface Flows Driven by Planetary Libration

MICHAEL CALKINS, JEROME NOIR, JEFF ELDREDGE, JONATHAN AURNOU, University of California, Los Angeles — Longitudinal libration is a non-zero mean, time-periodic variation in a planetary body's rotation rate. The outermost solid shells of numerous planetary bodies in the solar system —including Mercury, Europa, and Earth's moon— are currently librating. This libration is capable of driving flows in these planets' liquid metallic cores and subsurface oceans through viscous, topographic or electromagnetic couplings. We have carried out a suite of laboratory and numerical hydrodynamic libration experiments in sphere and spherical shell geometries. This set-up allows us to focus, at present, on the purely viscous coupling problem. Laboratory experiments demonstrate that longitudinal libration is capable of generating time-periodic centrifugal instabilities near the librating solid boundary, as well as inertial waves and zonal flows in the fluid interior. In an effort to apply these results to librating planets, we have carried out axisymmetric numerical simulations that access more extreme parameter values than can be reached in the laboratory experiment. These simulations show that the nonlinear interaction of inertial waves is the primary mechanism responsible for the zonal flow generation, whereas the Reynolds stresses generated from centrifugal instabilities only weakly influence zonal flow strength.

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