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Flows driven by libration, precession, and tides, in planetary cores

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Because of gravitational interactions with their companions, the rotational dynamics of planets involve periodic perturbations of their shape, the direction of their rotational vector, and their rotation rate. These perturbations correspond in planetary terms to tides, precession, and longitudinal libration. I will review the flows driven by those mechanical forcings in the liquid iron core of planets, as well as their possible consequences on the planetary dynamics. Special focus will be placed on the associated instabilities and on the various routes toward turbulence recently studied, combining laboratory experiments and numerical simulations. The key point is that mechanical forcings do not provide the energy to the excited flows: They convey part of the available rotational energy and generate intense fluid motions through the excitation of localized jets, shear layers, and resonant inertial modes. Hence, even very small forcings - as it is the case in planets - may have large scale consequences. Mechanically driven flows thus play a fundamental role in planets, providing for instance alternative mechanisms to the standard convective models in explaining the puzzling past magnetic fields recorded on Moon and Mars, and in rationalizing the variety of shapes and rotational states observed in exoplanets.