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Steady flows in the core of precessing planets : effects of the geometry and an applied magnetic field.

Raphael Laguerre[1], Aymeric Houliez[1], David Cébron[2], and Véronique Dehant[1]
[1]Royal Observatory of Belgium, Brussels, Belgium (raphael.laguerre@oma.be)
[2]Université Grenoble Alpes, CNRS, ISTerre, F-38000 Grenoble

The Earth is submitted to the gravitational effect of different objects, resulting in small variations of the orientation of its axis rotation. The precession corresponds to the rotation of the body spin axis around the normal to the elliptic plane. The primary flow forced by precession in a sphere is mainly a tilted solid body rotation, a flow of uniform vorticity. In this study we focused on the pseudo-resonance between the precessional forcing and the spin-over mode, detected as a peak of amplitude of the norm of the vorticity of the fluid. We show the influences of both the geometry and the application of an uniform external magnetic field on the external boundary, onto this pseudo-resonance. The major purpose is to validate a semi-analytical model to allow its interpolation to planetary bodies. We compared the semi-analytical model [Noir and C ́ebron, 2013] with numerical simulations performed with XSHELLS [Schaeffer, 2013], which give us the components of the fluid vorticity in a precessing frame. We compared also the spin-over mode coefficients, used to simulate the viscous effect on the model, with two methods : an empirical equation and the numerical solver Tintin [Triana et al., 2019], taking into account the solid inner-core size (η=RI/R). The differential rotation between the flow and the container, obtained with the model and the XSHELLS simulations, show us a verygood agreement especially for a small Ekman number (E= 10^−5), thus the spin-over mode coefficients for small E and η≤0.5. An increase of the inner-core size implies a decrease of the resonance amplitude caused by the supplementary Ekman layer added at the Inner Core Boundary (ICB); nevertheless thecolatitude (αf) and the longitude (φf) of the fluid don't change significantly.The application of a uniform magnetic field at the CMB implies a decrease of the resonance amplitude, but also a modification of the mean rotation axis direction. Indeed, the coupling between the viscous flow and the magnetic field induces a modification of the αfand φf, which follow the main direction angle of the magnetic field axis. We observe small discrepancies between the simulations (XSHELLS and Tintin) and the model but the behavior following different parameters (Po,α angle,Ro,η,β angle, Λ) is well understood. As a result, we applied the models at few parameter "realistic values" of planetary objects like terrestrial planets but also ice's satellites.

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