Topographic drag at the core-mantle interface

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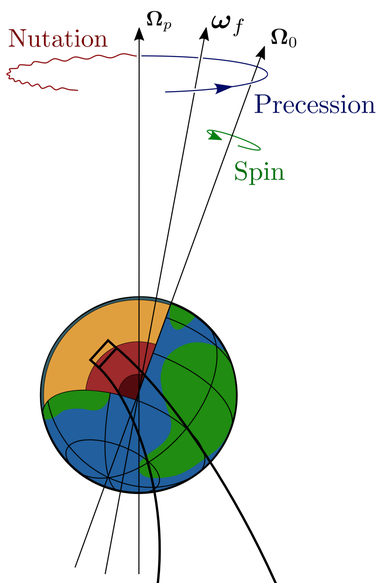
Description of the problem

Earth and Moon's rotations are tracked accurately, and data are inverted with rotation models

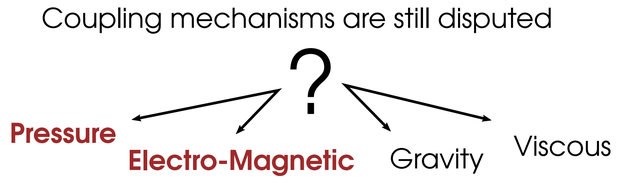
This provide **coupling** values between the outer core and the mantle/the inner core

Forward physical models failed to explain:

- decadal changes in the **Length-of-Day** and the concomitant changes in axial core angular momentum
- out of phase component of the **retrograde annual nutation**



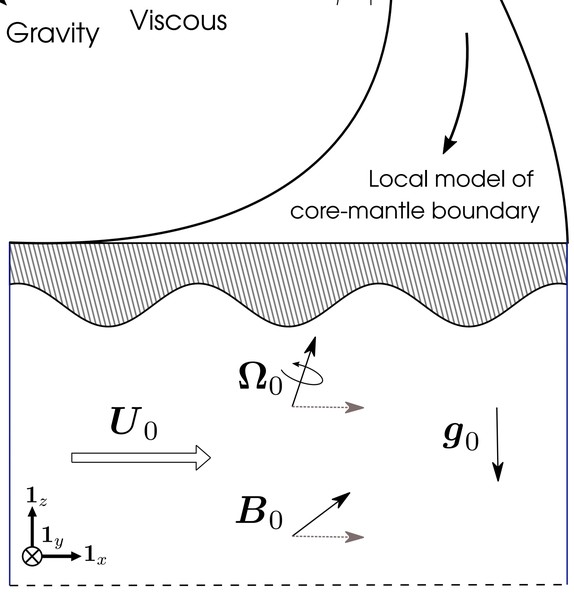
Coupling mechanisms are still disputed



Key effects:

- Stratification
- Magnetic field
- Rotation

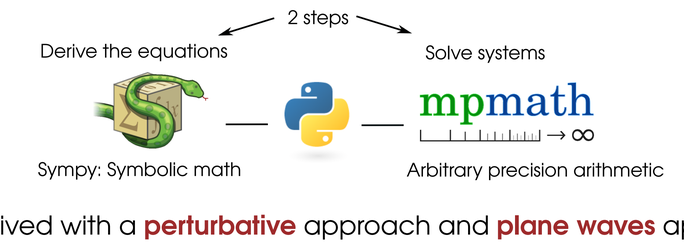
Modelling the topographic **core-mantle coupling** is a long-standing issue dating back to Hide (1969)[1] or Braginsky (1998)[2]. By first following the recent work of Glane & Buffett (2018)[3] and Jault (2020)[4] on the LOD, we revisit the **Cartesian perturbative models** of **incompressible Boussinesq** hydro-magnetic flow over a **bumpy topography**.



Sketch of the physical problem

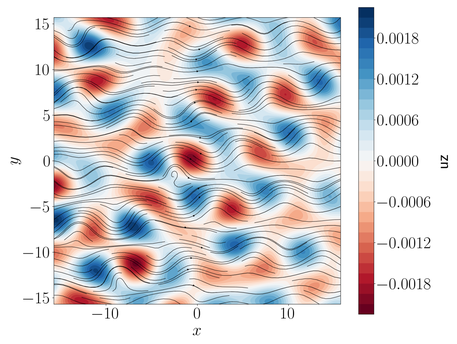
Methods

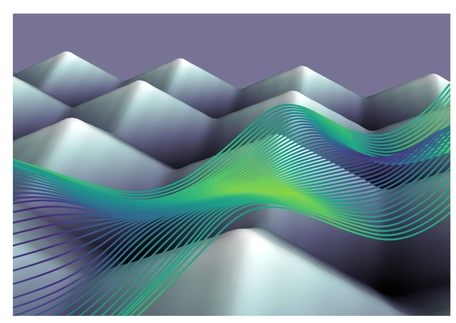
Our code **ToCCo** rely on symbolic and arbitrary precision calculations



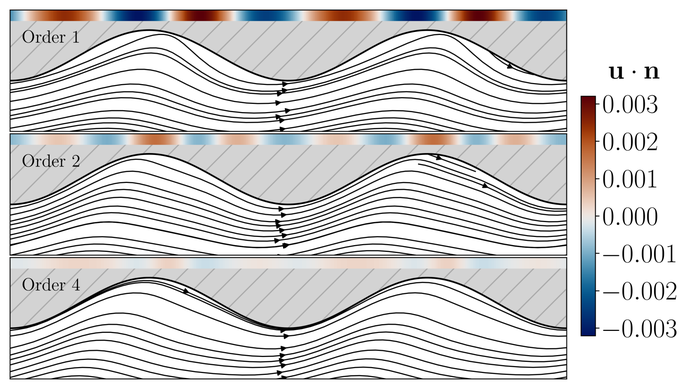
Equations are derived with a **perturbative** approach and **plane waves** approximation

We can explore **arbitrary topography** decomposed into Fourier series





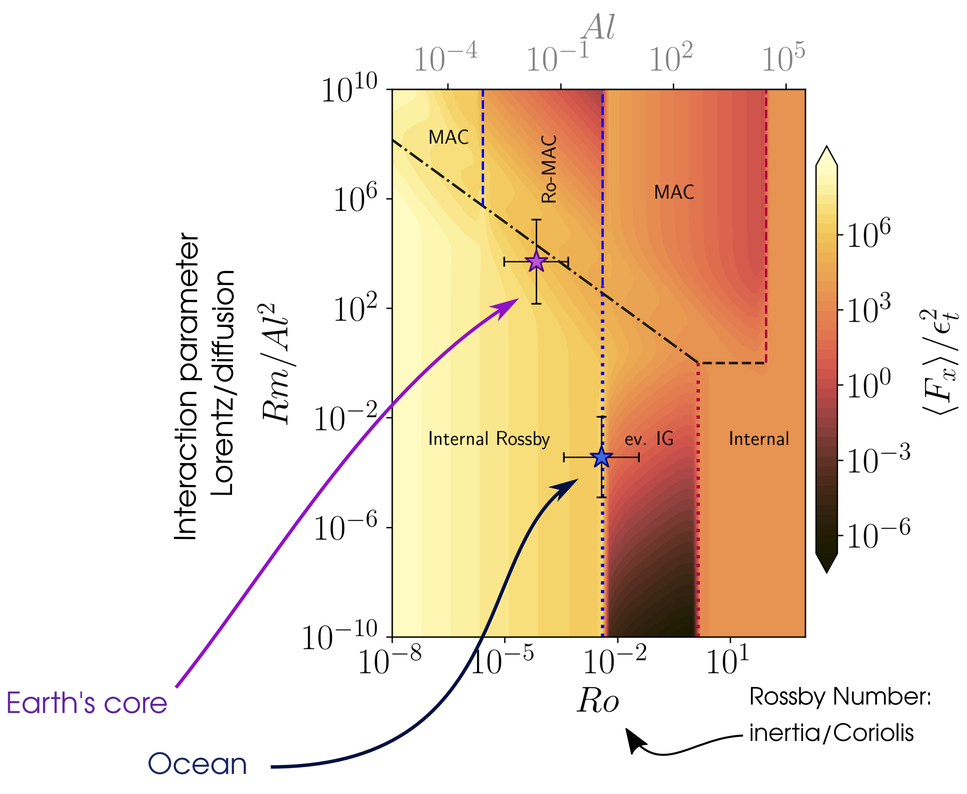
Our **"higher-order"** solutions go beyond the **forced wave** linear regime by investigating **non-linear effects.**



Results

Topographic wave drag

Stress variations with physical parameters of the problem are non-trivial, and it turns out, that the Earth's core is unexpectedly at the frontiers of various regimes.



These variations are due to transitions between stress dominated by **ohmic dissipation** or by the **wave drag** due to the propagation of the **various hydromagnetic waves**.

Data : application to length of the day

Parameters needed to obtain **the nominal value** for mean longitudinal stress[4] : 0.027 N.m^{-2}

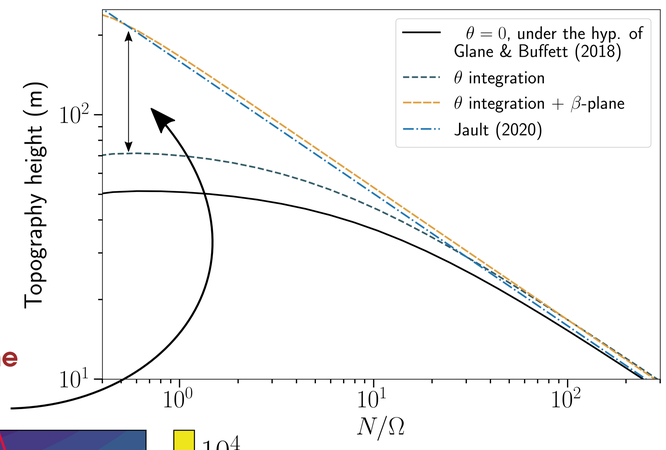
Large modifications of calculated stress when including **variation of magnetic field and rotation vectors with the colatitude**

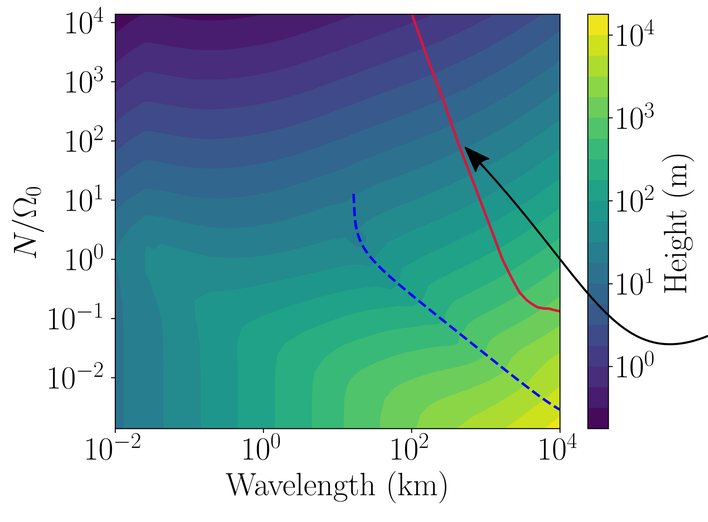
↓

at order 0: **integration** of local values on the sphere

↓

and order 1: **extended β -plane effects** of Dellar (2011)[5]





→ **Integrated in θ**

Model of CMB topography

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ToCCo:

[1] R. Hide, Nature 1969, 222, 1055.
[2] S. I. Braginsky, Earth, Planets and Space 1998, 50, 641.
[3] S. Glane, B. Buffett, Frontiers in Earth Science 2018, 6..
[4] D. Jault, Geophysical Journal International 2020, 221, 951
[5] P. J. Dellar, Journal of Fluid Mechanics 2011, 674, 174.
Our paper : R.Monville et al., JGR Solid Earth 2025 (published soon)