STABILITY OF MECHANICALLY-DRIVEN FLOWS IN ROTATING ELLIPSOIDS

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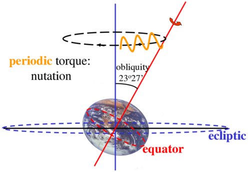
Mechanical forcings in geophysics

- Due to gravitational torques,
- Ex: **precession**, **librations**. . .
- Consequences:
  - **Non-spherical** geometry,
  - Rotation vector $\boldsymbol{\Omega}(t)$.



Observations

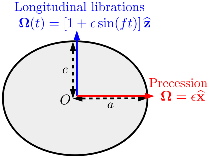


Illustration of the model

Global stability analysis in ellipsoids rotating at $\boldsymbol{\Omega}(t)$

- **Uniform vorticity** base flow $\mathbf{U_0} = \frac{1}{2}\boldsymbol{\omega} \times \mathbf{r} + \nabla \Phi$,
- Velocity perturbation $\mathbf{u}$: **finite-dimensional & polynomial vector space**,
- Governing equations

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{U_0} \cdot \nabla)\,\mathbf{u} + (\mathbf{u} \cdot \nabla)\,\mathbf{U_0} + 2\boldsymbol{\Omega}(t) \times \mathbf{u} = -\nabla \pi,$$

$$\nabla \cdot \mathbf{u} = 0.$$

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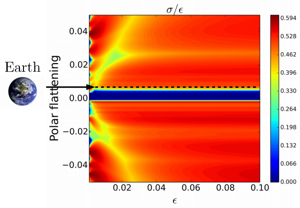
A few results

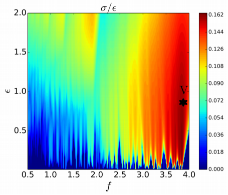
$\sigma =$ *linear growth rate*, ϵ*: forcing amplitude*, f *forcing frequency.*

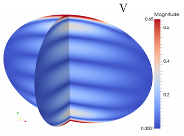
Precession



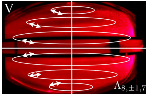
Instability for the Earth's flattening!

Longitudinal librations





Grannan et al., 2014



Good agreement with lab. experiment!

Inertial modes: a road to low-dimensional & weakly nonlinear models?

- Mechanically-driven instability = **parametric resonance** between a pair of free inertial modes and the base-flow,
- Inertial modes: **complete basis** for any incompressible flow.