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Magneto-inertial waves and planetary rotation

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Magnetic fields inside planetary objects can influence their rotation. This is true, in particular, of terrestrial objects with a metallic liquid core and a self-sustained dynamo such as the Earth, Mercury, Ganymede, etc. and also, to a lesser extent, of objects that don't have a dynamo but are embedded in the magnetic field of their parent body like Jupiter's moon, Io.
In these objects, angular momentum is transfered through the electromagnetic torques at the Core-Mantle Boundary (CMB) [1]. In the Earth, these have the potential to produce a strong modulation in the length of day at the decadal and interannual timescales [2]. They also affect the periods and amplitudes of nutation [3] and polar motion [4].
The intensity of these torques depends primarily on the value of the electric conductivity at the base of the mantle, a close study and detailed modelling of their role in planetary rotation can thus teach us a lot about the physical processes taking place near the CMB.

In the study of the Earth's length of day variations, the interplay between rotation and the internal magnetic field arrises from the excitation of torsional oscillations inside the Earth's core [5]. These oscillations are traditionally modelled based on a series of assumptions such as that of Quasi-Geostrophicity (QG) of the flow inside the core [6]. On the other hand, the effect of the magnetic field on nutations and polar motion is traditionally treated as an additional coupling at the CMB [1]. In such model, the core flow is assumed to have a uniform vorticity and its pattern is kept unaffected by the magnetic field.

In the present work, we follow a different approach based on the study of magneto-inertial waves. When coupled to gravity through the effect of density stratification, these waves are known to play a crucial role in the oscillations of stars known as magneto-gravito-inertial modes [7]. The same kind of coupling inside the Earth's core gives rise to the so-called MAC waves which are directly and conceptually related to the aforementioned torsional oscillations [8].

We present our preliminary results on the computation of magneto-inertial waves in a freely rotating planetary model with a partially conducting mantle. We show how these waves can alter the frequencies of the free rotational modes identified as the Free Core Nutation (FCN) and Chandler Wobble (CW). We analyse how these results compare to those based on the QG hypothesis and how these are modified when viscosity and density stratification are taken into account.

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