Precession driven dynamos

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It is widely accepted, that the planetary magnetic fields are powered by a magnetohydrodynamic dynamo-process. So far theoretical studies and numerical simulations have mostly assumed that the flow generating the dynamo-process is driven by buoyancy forces. But also precession can drive the dynamo, as first suggested by Bullard in 1949. A precession-driven laminar flow is mainly toroidal and cannot maintain a dynamo. However, experimental and numerical studies show that these basic flows are unstable and several kind of wave-like instabilities are generated. Therefore precession can also be regarded as a viable driving-mechanism of a core flow generating the planetary magnetic fields.

So far we have used a spherical, finite-volume code, already used for the simulation of convection-driven dynamos and mantle convection, to solve the equations of a precession-driven dynamo in a spherical shell. We investigated a full MHD-dynamo in a spherical shell, similar to that of Tilgner [1]. This flow can maintain a magnetic field but the magnetic field structure is not very similar to that of the Earth. For example the radial magnetic field at the outer boundary is not dipole dominated.

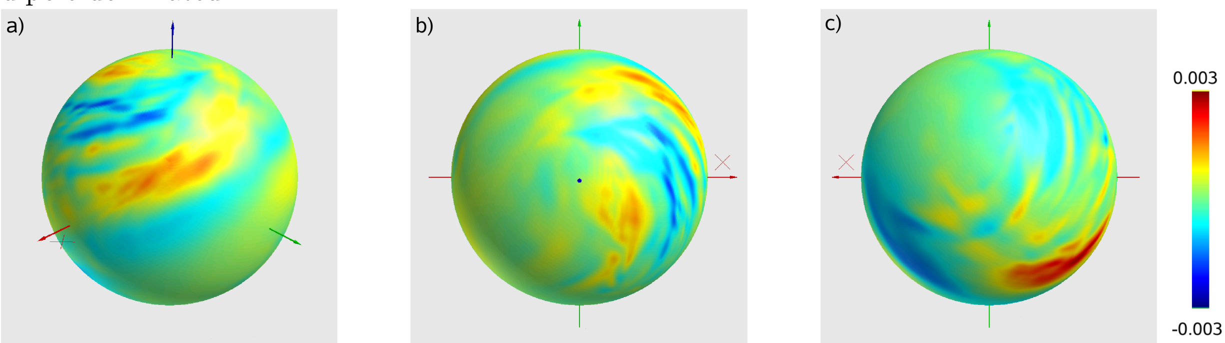

Figure 1: Snapshot of the radial magnetic field at the outer boundary from one side a), positive z-direction b) and from negative z-direction c). Parameters: precession rate $\Omega = -0.3$, obliquity $\alpha = 60°$, Ekman number $E = 3 \cdot 10^{-4}$, magnetic Prandtl number $Pm = 2$, inner core size $r_i = 7/13$.

Furthermore the non-sphericity of the planetary bodies trigger some crucial instabilities. However, up to now the only available full MHD study of precessing spheroids is [2]. Their preliminary results for a full spheroid showed that this topographic coupling offers more favourable conditions for the generation of a sizeable dipole component of the magnetic field. We shall discuss how the ellipticity of the planets can be included in our calculations through the use of a non-orthogonal grid.

References

[1] A. Tilgner. Precession driven dynamos. *Phys. Fluids*, 17(034104), 2005.

[2] C. C. Wu and P. H. Roberts. On a dynamo driven by topographic precession. *Geophys. Astrophys. Fluid Dynam.*, 103:467–501, 2009.