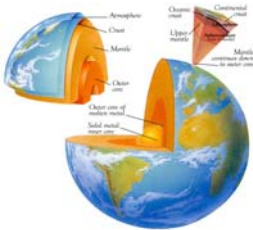


Preparing a rapidly rotating liquid sodium dynamo experiment

Equipe « Géodynamo ».

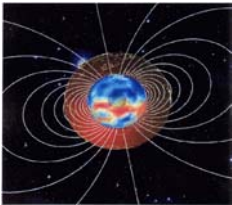
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THE STRUCTURE OF THE EARTH



Below the crust and the rocky mantle of the earth, the outer molten Earth's core is mainly composed of iron.

THE DEEP EARTH AND ITS MAGNETIC FIELD

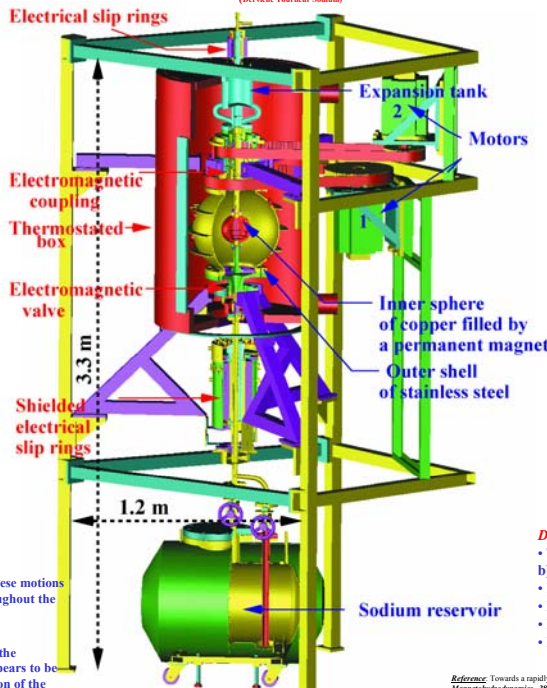


The liquid iron of the earth's core is convecting vigorously. These motions have been self-sustaining the magnetic field of the Earth throughout the history of the Earth by the so-called DYNAMO process.

The Earth's magnetic field is mainly dipolar and aligned with the Earth's rotation axis. The global ROTATION of the Earth appears to be an important parameter to take into account in the modelisation of the dynamics of the Earth's core.

DTS EXPERIMENT

(Dérivée Tourneur Sodium)



PRINCIPLE:

Rapidly rotating spherical shell filled with liquid sodium, in which motions are set by spinning at a different rotation rate an inner core permeated by a strong magnetic field.

GOAL:

Characterize the so-called magnetostrophic regime where the combined actions of Coriolis (rotation) and Lorentz (magnetic) are dominant in the flow. Estimate what is needed to reach the dynamo regime with a similar experiment, bigger in size.

INGREDIENTS:

- 40 liters of sodium.
- Stainless steel outer sphere of radius 21 cm.
- Copper inner sphere of radius 7.4 cm. (ratio outer/inner sphere= 0.35, Earth's like)
- 2 Motors of 10 kW.
- Imposed magnetic field (inner sphere) of 22 mT (mid-depth of the shell).

MEASUREMENTS:

- Ultrasonic Doppler velocimetry to measure the velocity of the fluid inside the shell.
- Differences in electrical potentials (probes in the outer sphere wall).
- Induced magnetic field outside the rotating outer sphere.

DIMENSIONLESS NUMBERS:

- Typical length, $a=0.21$ m, $b=0.074$ m, $L=b+(a-b)/2=0.142$ m
- Prandtl magnetic number $Pm=9.6 \cdot 10^{-6}$
- Reynolds number, $Re_{max}=(\Delta\Omega)_{max} \cdot b^2 \cdot L/\nu \approx 3 \cdot 10^6$
- Elsasser number $=(\sigma B^2)/(\rho \Omega) \approx 2 \cdot 10^{-2}$
- Magnetic Reynolds number, $Rem_{max}=\mu_0 \sigma (\Delta\Omega)_{max} b \approx 40$

Reference: Towards a rapidly rotating liquid sodium dynamo experiment P. Cardin, D. Brats, D. Jault, H.-C. Nataf and J.-P. Masson *Magnetohydrodynamics*, 38, No. 1-2, 177-189, 2002.

