



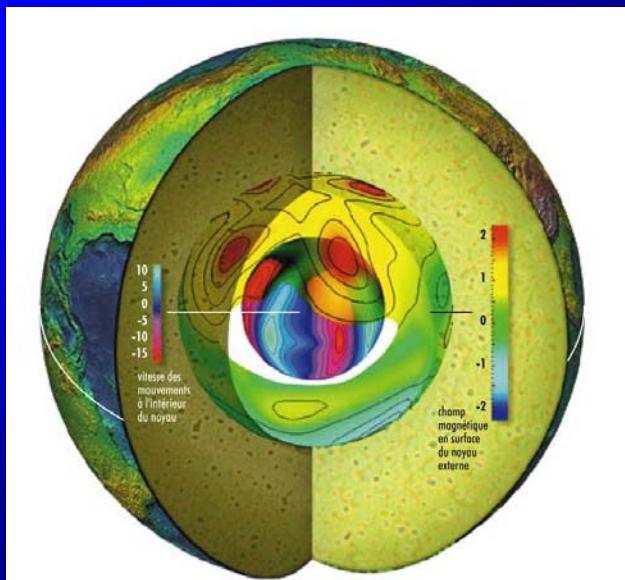
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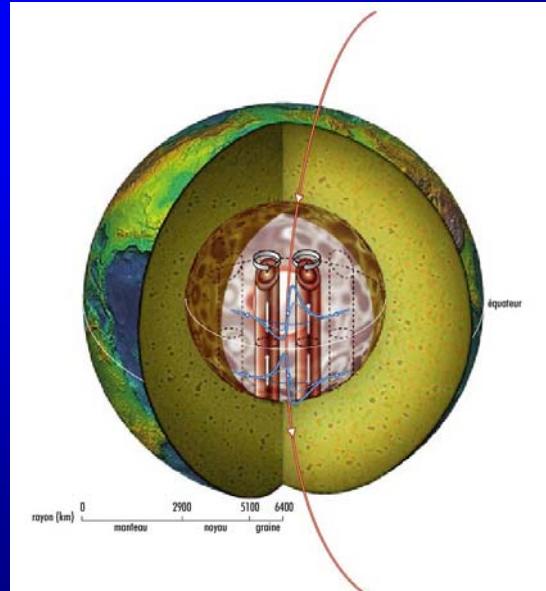
P. Cardin, D. Brito, D. Jault, H.-C. Nataf, J.-P. Masson
Observatoire de Grenoble, LGIT, France.



Earth's magnetic field⁺⁺



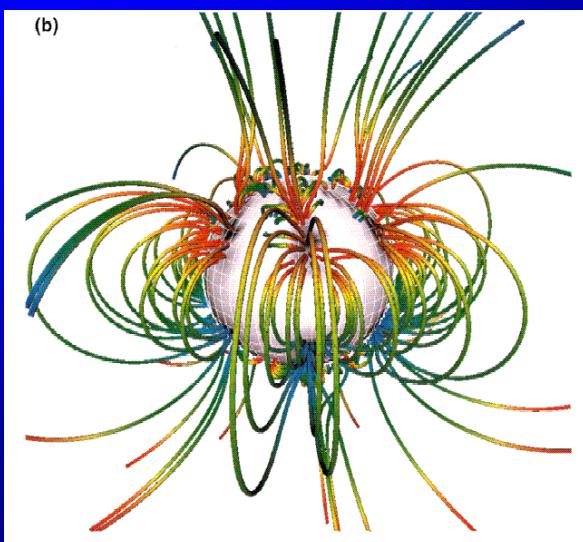
Dynamics of the Earth's Core



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Numerical Dynamos



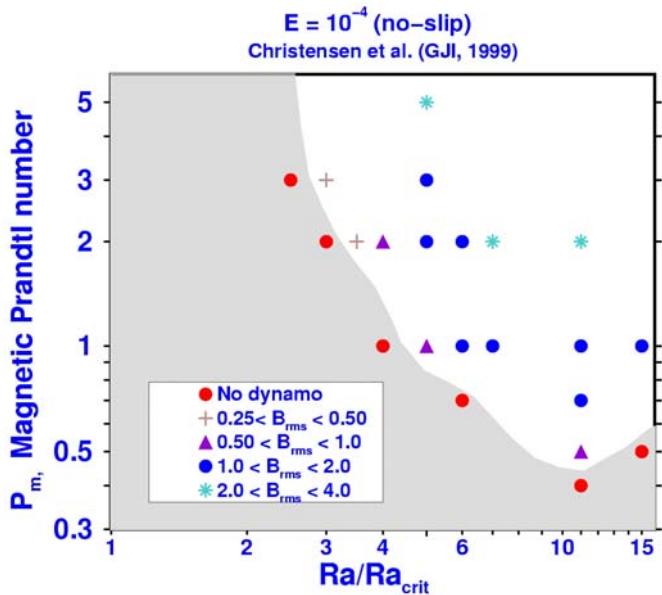
Kageyama and Sato

PRE, 1997



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To build an experimental planetary dynamo

1. Liquid metal $P_m \ll I$



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To build an experimental planetary dynamo:

1. Liquid metal $P_m \ll I$

2. Vigorous motions



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To build an experimental planetary dynamo:

$$R_m = \frac{Ua}{\eta} \approx 100 \quad \eta = 0.1 \text{ m}^2\text{s}^{-1}$$

1. Use liquid sodium (η)
2. Impose vigorous motion in a large container (U, a).

In the core, $R_m > 100$



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To build an experimental planetary dynamo:

1. Liquid metal $P_m \ll 1$

2. Vigorous motion $R_m = \frac{Ua}{\eta} \approx 100$

3. Rapid rotation



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Coriolis Vs Laplace forces

Waves:

- Rotation alone \rightarrow inertial waves : $[0,2] \Omega$
- Magnetic forces alone \rightarrow Alfvén waves : $\omega_a \sim (\mu_0 \rho)^{-1/2} B/a$
- $\lambda = \omega_a / \Omega = B / a \Omega (\mu_0 \rho)^{1/2}$

Rapid rotation means : $\lambda \ll 1$

In the Earth's outer core $\lambda \sim 3 \cdot 10^{-4}$



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To build an experimental planetary dynamo:

1. Liquid metal $P_m \ll 1$
2. Vigorous motion $R_m = \frac{Ua}{\eta} \approx 100$
3. Rapid Rotation $\lambda = \frac{\omega_{Alfven}}{\Omega} \ll 1$
4. Magnetostrophy



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Coriolis Vs Laplace forces

At long time scale :

$$\text{Lorentz} \sim \text{Coriolis} \rightarrow \Lambda = jB/2\rho U\Omega$$

Magnetostrophy means : $\Lambda \sim 1$

In the Earth's core, $0.1 < \Lambda < 10$



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To build an experimental planetary dynamo:

1. Liquid metal $P_m \ll I$
2. Vigorous motion $R_m = \frac{Ua}{\eta} \approx 100$
3. Rapid rotation $\lambda = \frac{\omega_{Alfven}}{\Omega} \ll 1$
4. Magnétostrophy $\Lambda \sim I$



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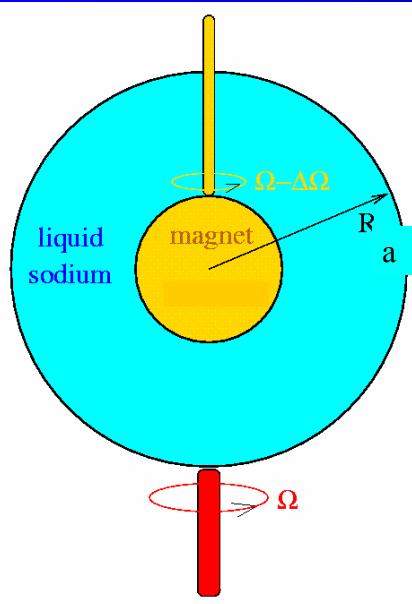
Planetary Dynamo

$$Power \approx C \frac{\rho \eta^3}{a} R_m^2 \frac{\Lambda_d^2}{\lambda^2}$$



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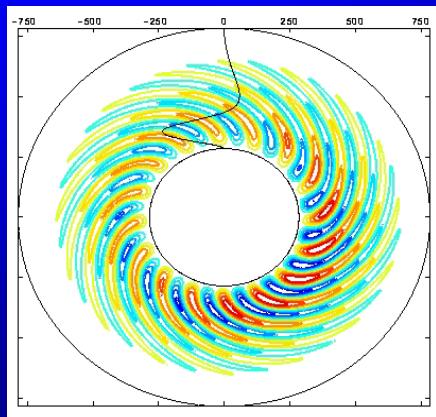
A planetary
Dynamo ?



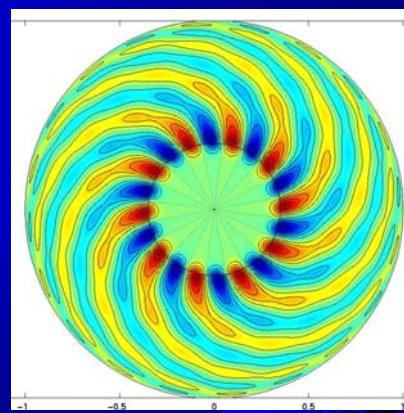
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Thermal convection



Differential rotation



$E=10^{-6}$



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Planetary Dynamo

$$R_m = 100$$

$$\lambda = 0.25$$

$$\Lambda_d \approx 1$$

$$a = 1 \text{ m}$$

$$\Omega = 450 \text{ rpm}$$

$$\text{Power} = 600 \text{ kW}$$

$$\Delta\Omega = 150 \text{ rpm}$$

$$B = 0.3 \text{ T}$$

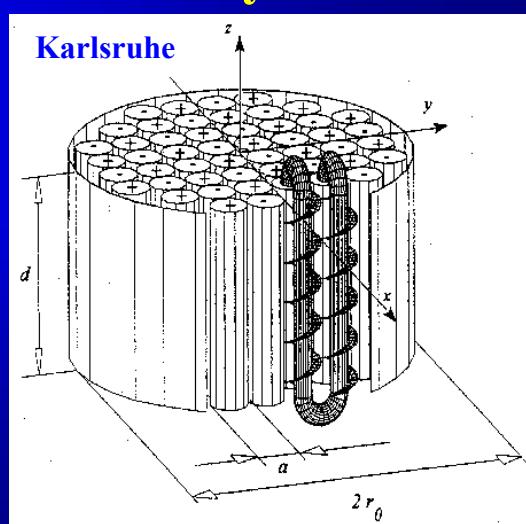
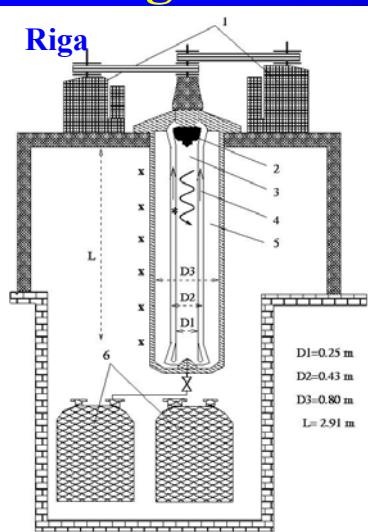


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Riga and Karlsruhe dynamos



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DTS

$$R_m < 30$$

$$\lambda > 0.01$$

$$\Lambda_i > 0.01$$

$$a = 0.21 \text{ m}$$

$$\Omega = 0\text{-}2000 \text{ rpm}$$

$$Power = 20 \text{ kW}$$

$$\Delta\Omega = \pm 0\text{-}2000 \text{ rpm}$$

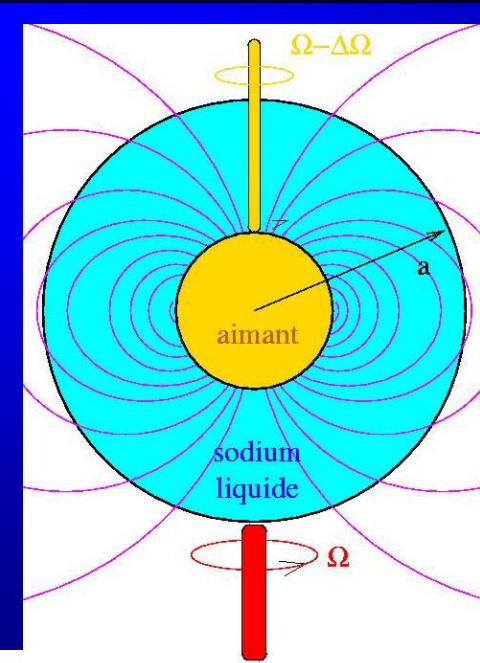
$$B = 20 \text{ mT}$$



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DTS
experiment



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DTS

$$R_m < 30$$

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$$a = 0.21 \text{ m}$$

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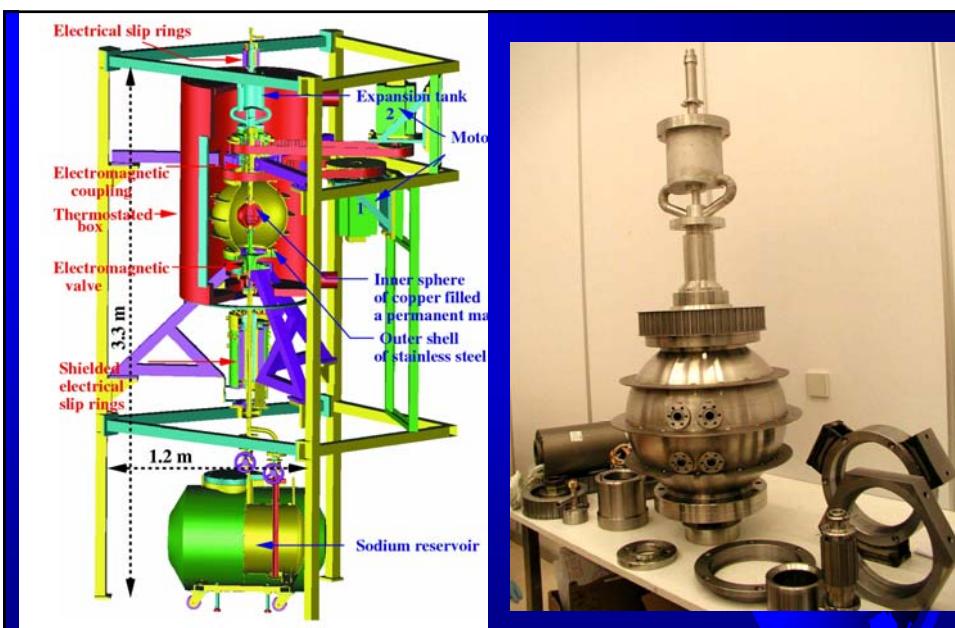
$$B = 20 \text{ mT}$$



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DTS : 40 liters sphere



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