

Influence of time-dependant flows in the dynamo onset

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Magneto-Hydrodynamic

- Why?
- Astrophysical: Terrestrial M-H, Sun,... galaxy
 - Plasma: Tomahawk
 - Industry: Metallurgy

- Basic equations:
- Eq Navier-Stokes + Lorentz force

$$\frac{\partial \vec{v}}{\partial t} + (\vec{v} \cdot \nabla) \vec{v} = -\frac{1}{\rho} \nabla P + \nu \nabla^2 \vec{v} + \frac{1}{\rho m \mu_0} (\nabla \times \vec{B}) \times \vec{B}$$

- Eq. MHD

$$\frac{\partial \vec{B}}{\partial t} + (\vec{v} \cdot \nabla) \vec{B} = \underbrace{Rm(\vec{B} \cdot \nabla) \vec{v}}_{\text{Injective term}} + \underbrace{\nabla^2 \vec{B}}_{\text{Diffusive term}}$$

$Rm = U L \mu_0 \sigma$ Reynolds Magnetic Number
 $Re = U L / \nu$ Reynolds Hydrodynamic Number
 $Pr = Rm / Re$ Prandtl Number

- In real world, $\frac{1}{\mu_0 \sigma} > \nu$
- Even for Sodium at 150°C $Pr = 10^5 \Rightarrow Re = 10^5$ Fully-Developed Turbulence
- Ways to abboard the problem:
 - Theoretical } Can't solve the problem completely
 - Numerical }
 - Experimental }

"...in MHD, one should not believe the product of a long and complicated piece of mathematics if unsupported by observation..."

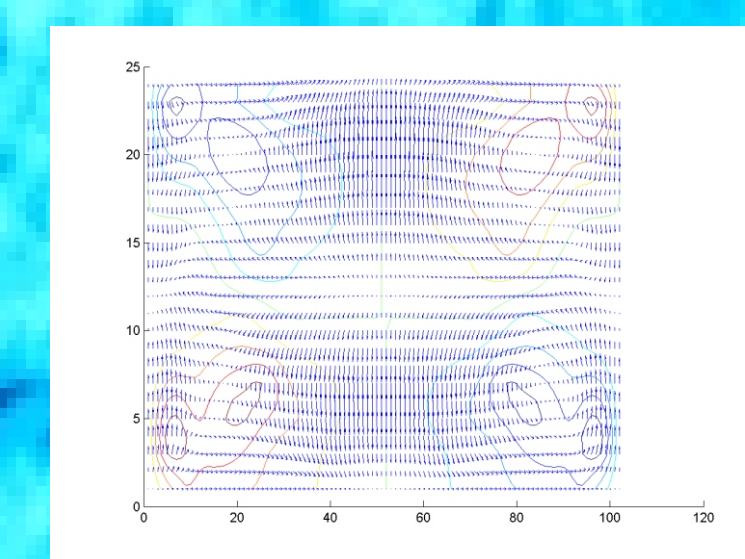
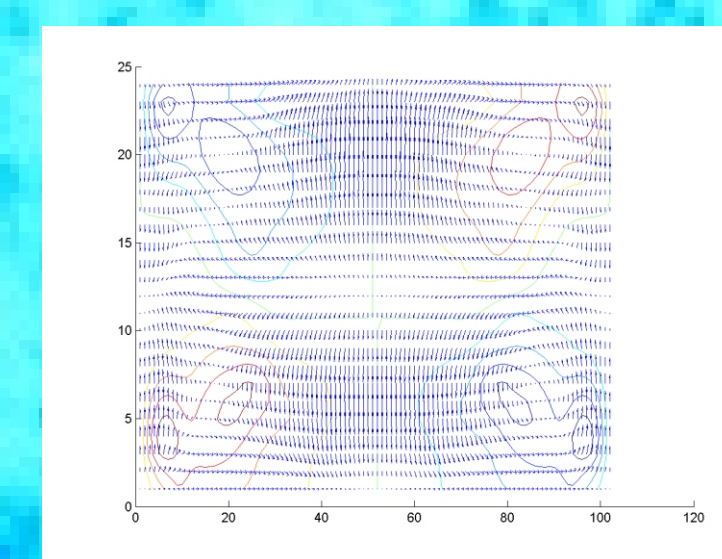
E. Fermi

Dynamo Effect

- Dynamo effect: Self-excitation of a \vec{B} in a moving conductive fluid
- Kinematic dynamo: Below the threshold of the dynamo effect, \vec{v} is not affected by \vec{B} in the MHD equation, so $\vec{v} \neq \vec{v}(\vec{B})$
- Aproximations in the MHD equation : $\tau_B < \tau_{Iny} \Rightarrow \vec{v} \neq \vec{v}(\vec{B})$
 \vec{v} is axisymmetric
- Our study:-- Although $\tau_B \ll \tau_{Iny}$, for $Re \sim 10E5$ there are $t \sim \tau_B$
 - \vec{v} is not axisymmetric

Simulations

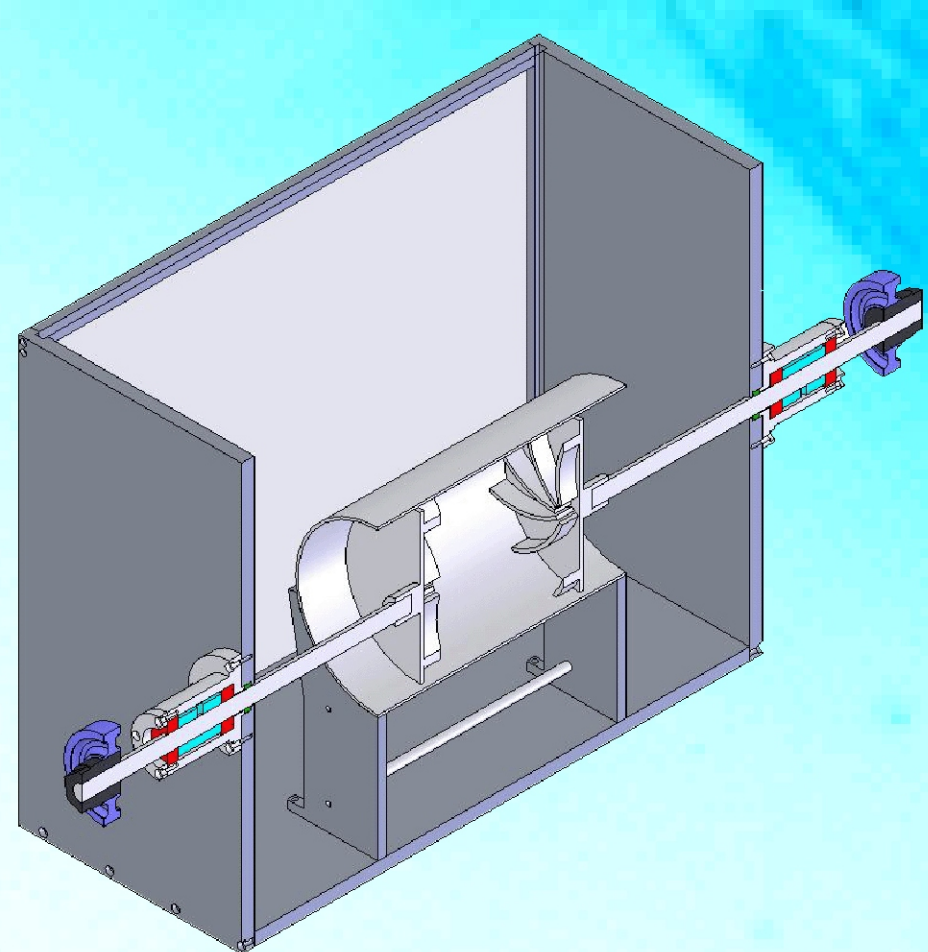
- Simulate the MHD equation for the measured \vec{v}
- r-axis: - Method :Finite differences
 - Boundary conditions: $r=R$ Isolant
- z-axis: - Method: Spectral
 - Boundary conditions: Periodic at $z=0,L$
- We obtain $E = \frac{1}{2} \int B dV \sim e^{\sigma t}$ and characterize sigma.



Experimental procedure

- Hydrodynamic of time-dependant von Kármán flows
 - With PIV (Particle Image Velocimetry) & LDV (Laser-Doppler velocimetry)
 - Natural & Forced time-dependence
- Sustitute Sodium by Water:

	ν	ρ
Na at 120°C	0.6 cp	0.86 gr/cm ³
H2O	1 cp	1 gr/cm ³



Preliminary results

- Simulations with $\vec{v}(t) = \vec{v}_m + \vec{v}_d \cdot \cos(\omega t)$ being \vec{v}_m, \vec{v}_d time-averaged experimental fields, dynamo or non-dynamo producers.
- We demonstrate that growth rate and activation Rm varies when the mean-flow is time dependent