Steady states in visco-resistive MHD in tokamaks

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Study of steady states in JET and ITER configurations

$$(v.\nabla)v = J \times B - \nabla p + \nu \nabla^2 v \quad \text{Force Balance} \quad (1)$$

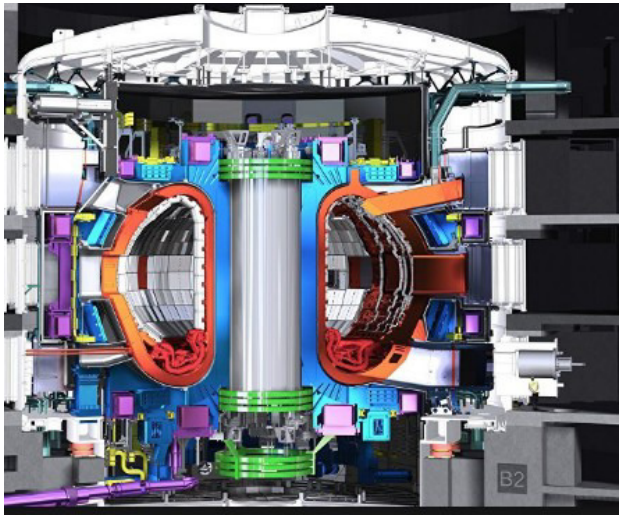
$$E + v \times B = \eta J \quad \text{Ohm's law} \quad (2)$$

$$\nabla \times B = \mu_0 J \quad (3)$$

$$\nabla \times E = 0 \quad \text{Faraday's law} \quad (4)$$

$$\nabla . v = 0 \quad \text{incompressibility condition} \quad (5)$$

$$\nabla . B = 0 \quad (6)$$



This system of equations is solved with the Finite Element Method (FEM) using FreeFem++ open source in toroidal geometry with axisymmetry.

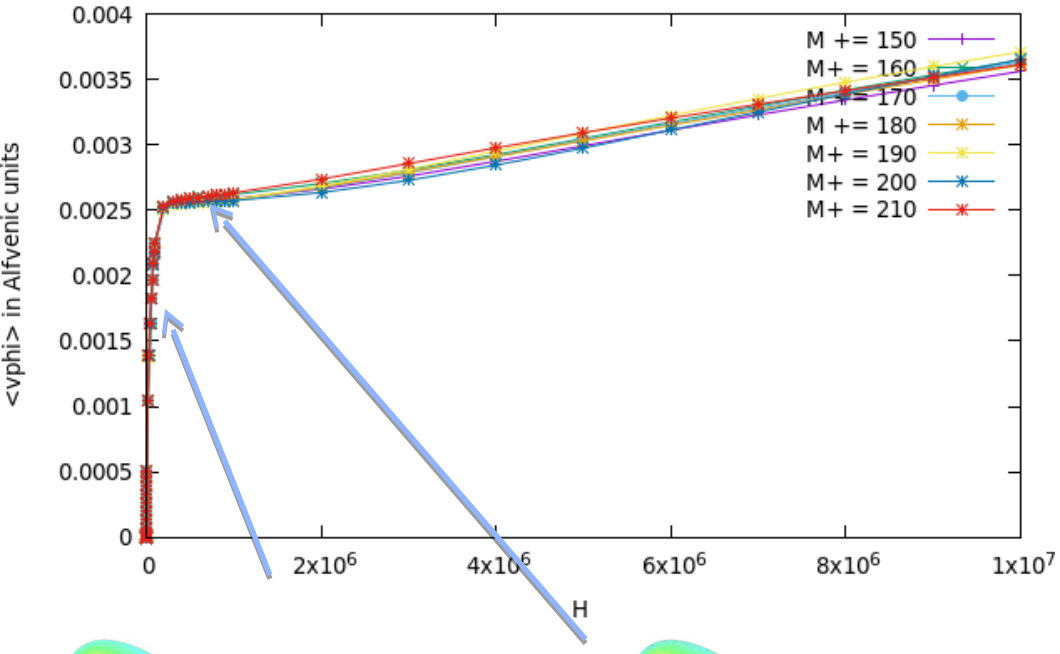
We fix the resistivity η and we vary the viscosity through the Hartmann number $\mathbf{H= (\eta\nu)^{-(1/2)}}$

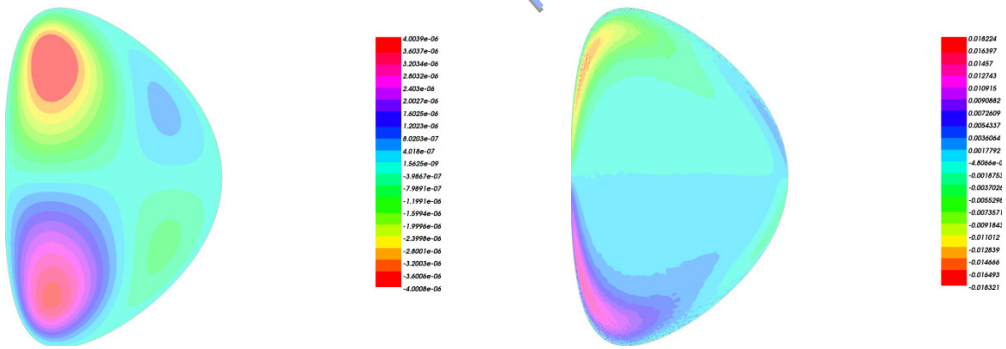
The system of **non linear** coupled equations was solved for **no slip boundary** conditions : we impose that the velocities at the walls are zero. We impose the external electric and magnetic fields.

$$B_{ext}(r, z) = B_0 \frac{r0}{r} i_\varphi \qquad E_{ext}(r, z) = E_0 \frac{r0}{r} i_\varphi$$

Numerical Results in ITER and JET configurations using FreeFem++

JET parameters: R=3m, r=1.25m, η=6.7e-7cm²/s , Toroidal B = 0.87T





Device	V (km/s)
C-Mod	0-130
DIII-D	0-30
JET	0-60
JT-60U	0-120
TCV	35
Tore-Supra	0-80
ITER	?

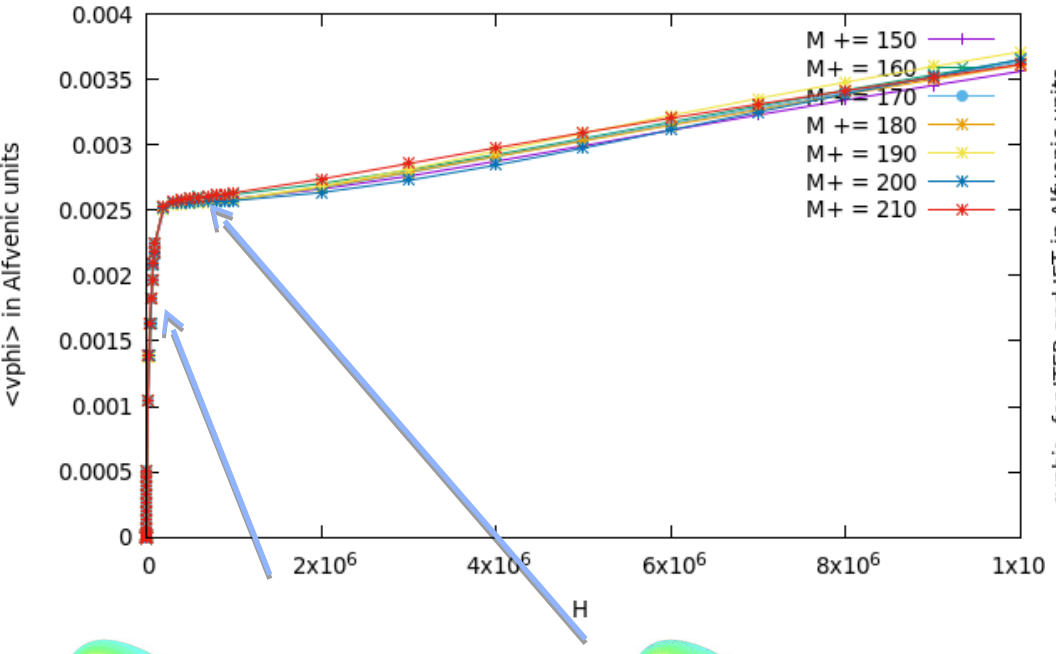
Some **experimental** results for spontaneous rotation

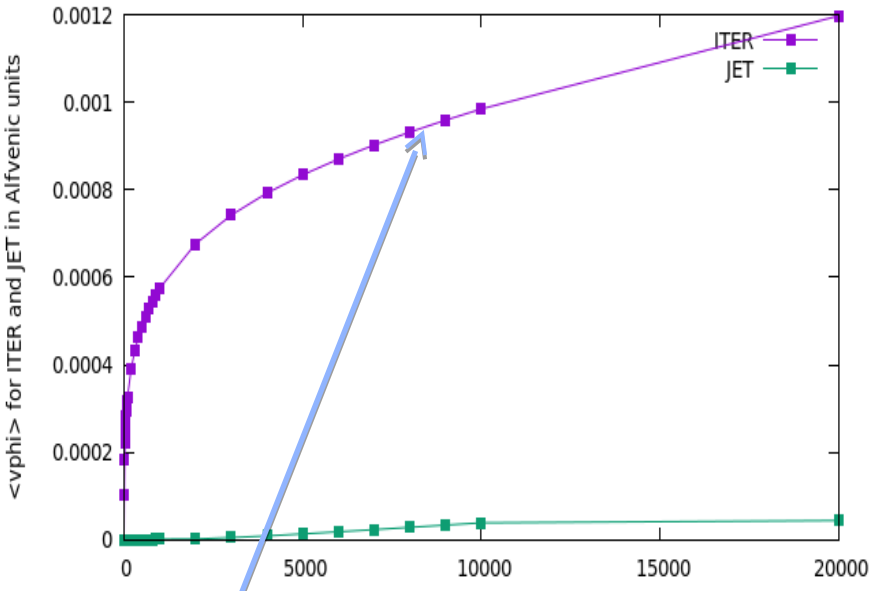
Vphi (Km/s)	Experimental values	Numerical values
JET	0-60	25

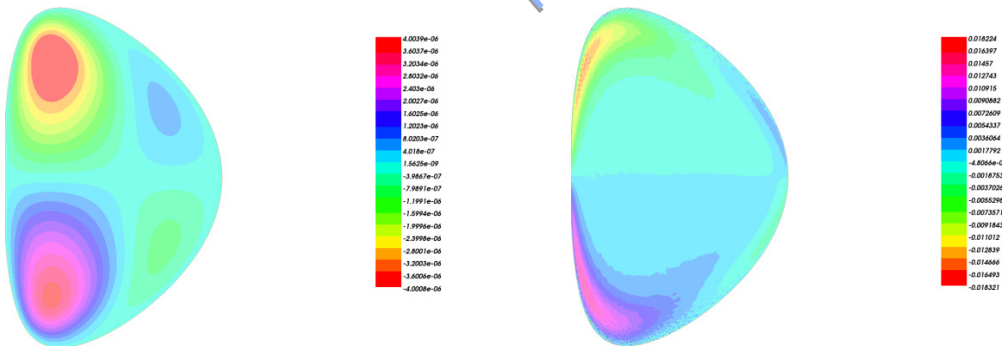
Numerical Results in ITER and JET configurations using FreeFem++

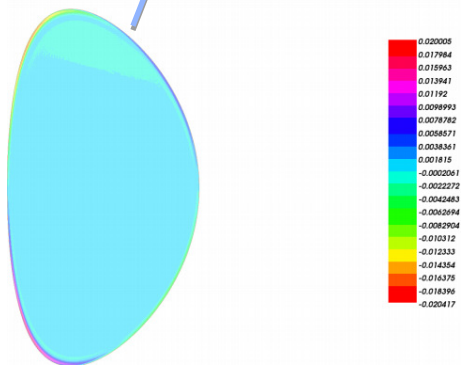
JET parameters: R=3m, r=1.25m, η=6.7e-7cm²/s , Toroidal B = 0.87T

ITER parameters: R=6.2m,r=2m, η=6.7e-9cm²/s , Toroidal B =5T









Toroidal mean square velocities are **larger** in **ITER** than in **JET**