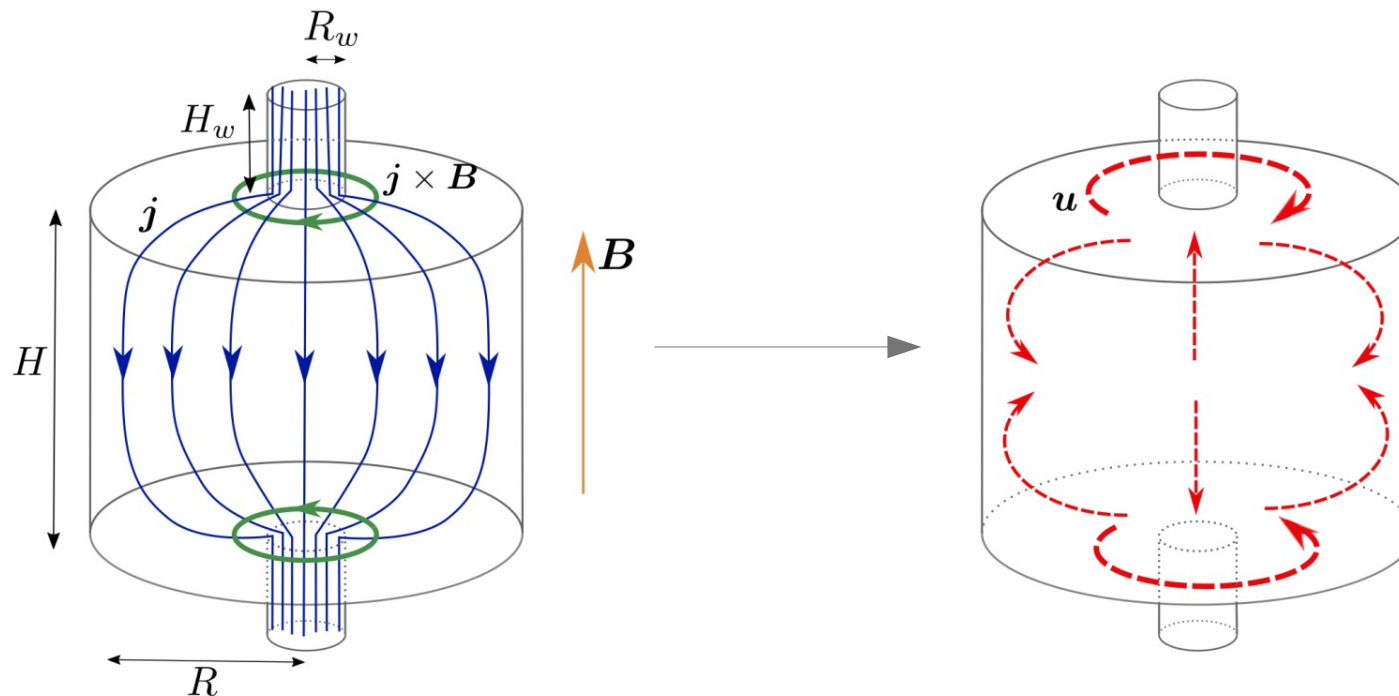# Numerical simulations of Swirling Electro-vortex Flow in cylinders

S. Bénard, W. Herreman, J. L. Guermond and C. Nore

Prototype : cylinder filled with Galinstan (GaInSn)

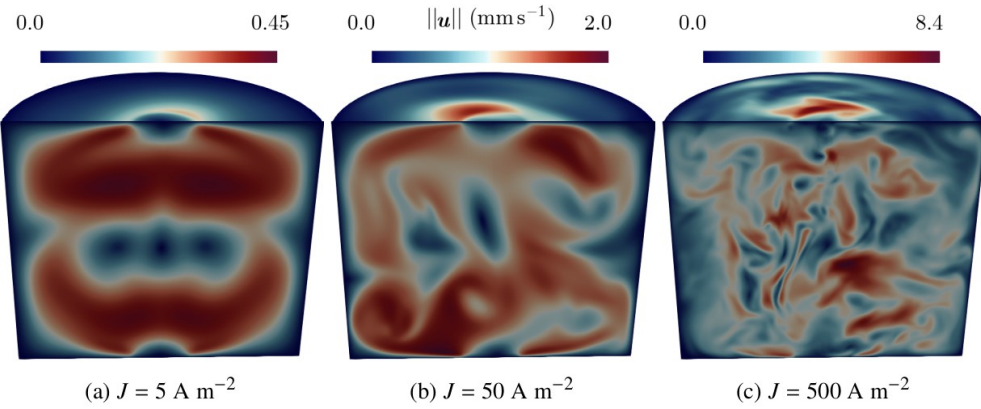Imposed external magnetic field B and current density in the cylinder J.

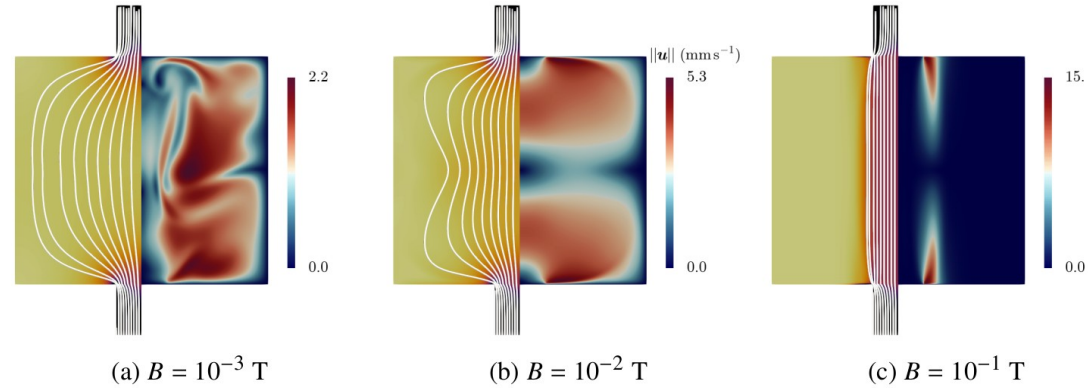**How does the flow's intensity vary with the different parameters?**

Are there major differences between axisymmetric and three-dimensional simulations?
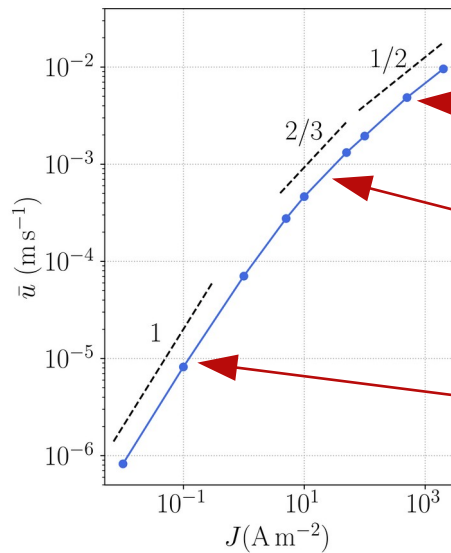
What are the different regimes of the flow?

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Different types of flows

(a) $J = 5$ A m^{-2} (b) $J = 50$ A m^{-2} (c) $J = 500$ A m^{-2}

Distribution of the flow in the cylinder for different J

(a) $B = 10^{-3}$ T   (b) $B = 10^{-2}$ T   (c) $B = 10^{-1}$ T

Current (left) and flow field (right) in the cylinder for different B

Four flow regimes

- Induction-less:
  - inertial

  $$U \sim \left(\frac{JBR}{\rho} \right)^{1/2}$$

  - boundary layer

  $$U \sim \left(\frac{JB}{\rho} \right)^{2/3} \frac{R}{\nu^{1/3}}$$

  - viscous

  $$U \sim \frac{JBR^2}{\rho \nu}$$

- Inductive:

  $$U \sim \frac{J}{\sigma B}$$