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Transport à travers une barrière générée par une source de moment poloïdal

(code GYSELA)

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IRFM-CEA: X. Garbet, Y. Sarazin, V. Grandgirard

Colloque FR-FCM, Montauban, 19-20 mai 2022

1. **Impurity transport (PhD K. Lim)**

2. **Vorticity source in GYSELA (PhD G. Lo-Cascio)**

    → **barrière de transport**

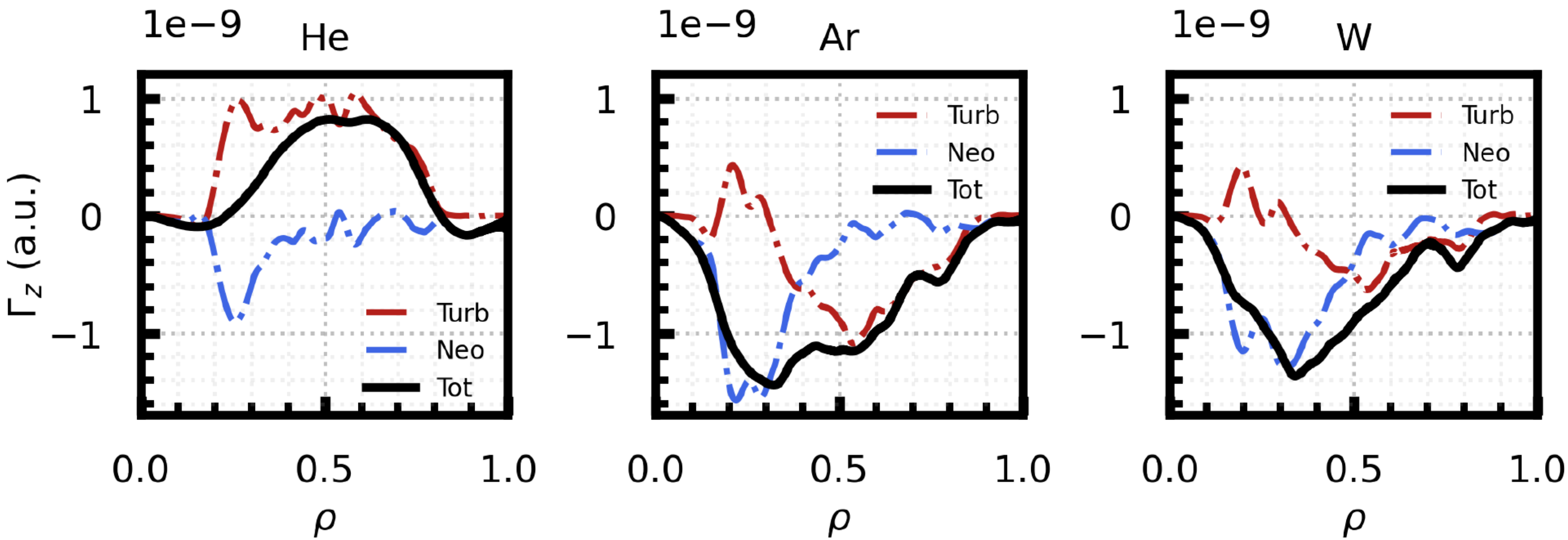
    → **TSVV#6 (transport d'impuretés)**

3. **Cylindrical geometry - SPEKTRE**

1. Impurity transport (PhD K. Lim)

Vlasov equation + collision operator

Turbulent transport + neoclassical transport



Contrats FR-FCM
Thèse co-financée région Grand-Est,
IRFM-CEA et IJL

[Lim, PPCF 2020]

[Lim, Nucl. Fusion 2021]

[Lim, PhD thesis, UL, 2021]

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2. Vorticity source in GYSELA

Characterize how this vorticity source behaves in GYSELA

$$S = S_r(\rho) \sum_{l=0}^{\infty} \sum_{h=0}^{\infty} c_{hl} H_h(v_\parallel) L_l(\mu) e^{-v_\parallel^2 - \mu B}$$

$$\frac{\partial f}{\partial t} + \frac{1}{B_\parallel^*} \nabla_{\mathbf{r}} . \left(f B_\parallel^* \mathbf{v}_{GC} \right) + \frac{1}{B_\parallel^*} \frac{\partial}{\partial v_\parallel} \left(f B_\parallel^* \dot{v}_\parallel \right) = \mathcal{C} + S$$

Focus on the **vorticity source (source of poloidal velocity)**:

$$S = S_r(\rho) c_{01} (2 v_\parallel^2 - \mu B) e^{-v_\parallel^2 - \mu B}$$ (kinetic source)

$$\int .J_0 d\vec{v}$$

$$S_\Omega = S_{0_\Omega} \nabla_\perp^2 S_r$$ (fluid source)

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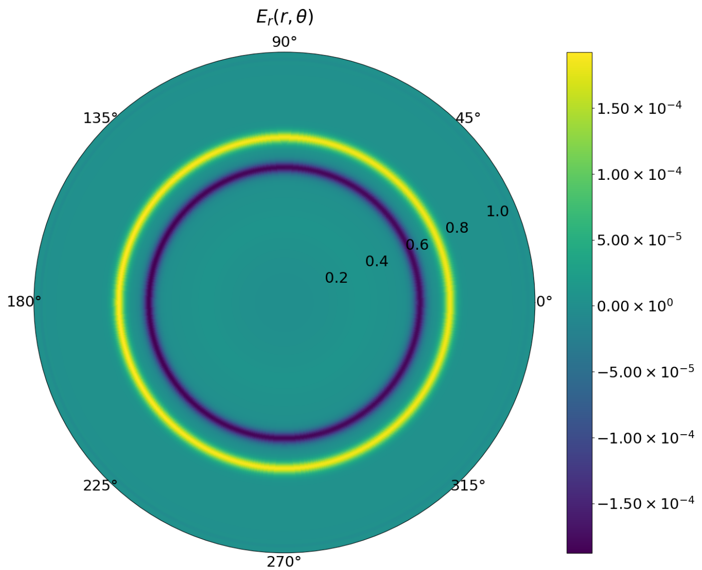
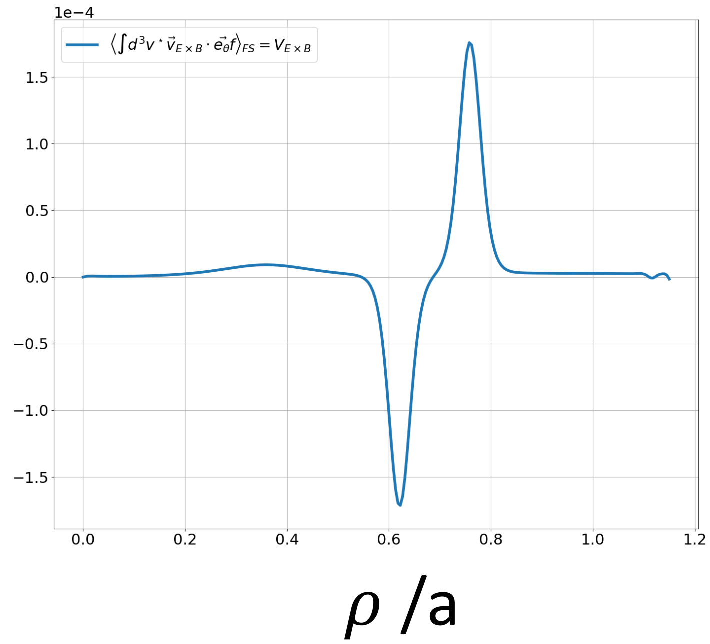
2. Vorticity source in GYSELA

Characterize how this vorticity source behaves in GYSELA

Radial electric field in a poloidal cross section



***ExB* velocity**



2. Vorticity source in GYSELA

Generate a transport barrier in ITG-dominated regime

$$\frac{\partial f}{\partial t} + \frac{1}{B_{\parallel}^{*}} \nabla_{\mathbf{r}} . \left(f B_{\parallel}^{*} \mathbf{v}_{GC} \right) + \frac{1}{B_{\parallel}^{*}} \frac{\partial}{\partial v_{\parallel}} \left(f B_{\parallel}^{*} \dot{v}_{\parallel} \right) = \mathcal{C} + S$$

- $N_r \times N_\theta \times N_\phi \times N_{v_\parallel} \times N_\mu = 511 \times 512 \times 64 \times 127 \times 32$
- Flux driven
- $\rho^* = 1 / 200 = \rho_{\mathrm{Li}} / a$
- Deuterium ions
- Adiabatic electrons
- $\kappa_n = 2.2$ and $\kappa_T = 6.6$ ($\eta = 3$) **ITG dominated regime**

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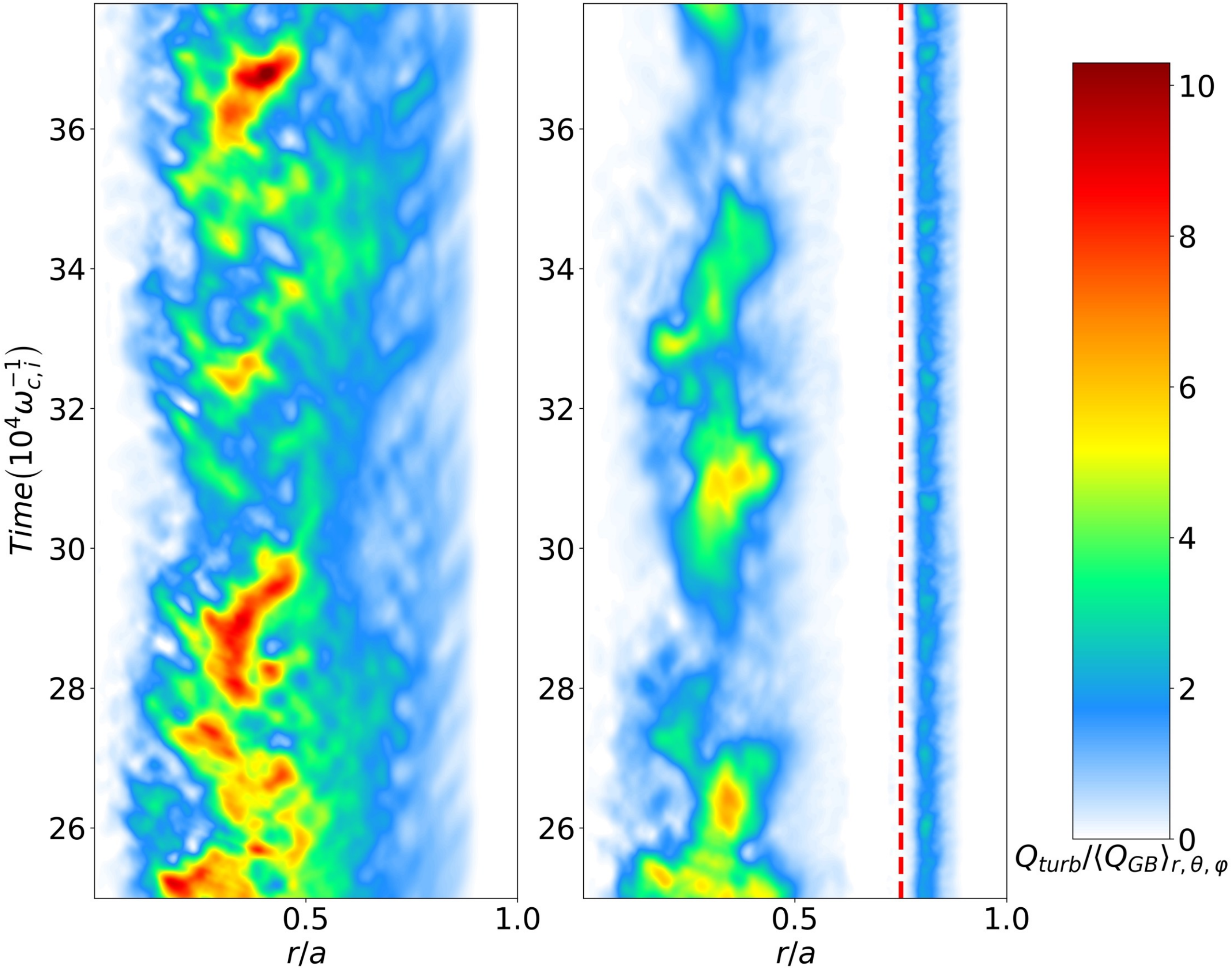
2. Vorticity source in GYSELA



HEAT FLUX

reference case **vorticity source case**

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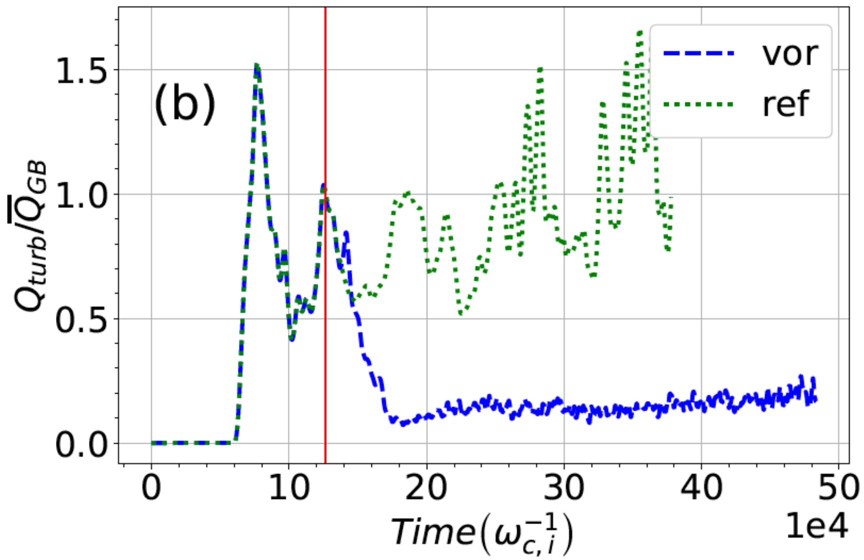
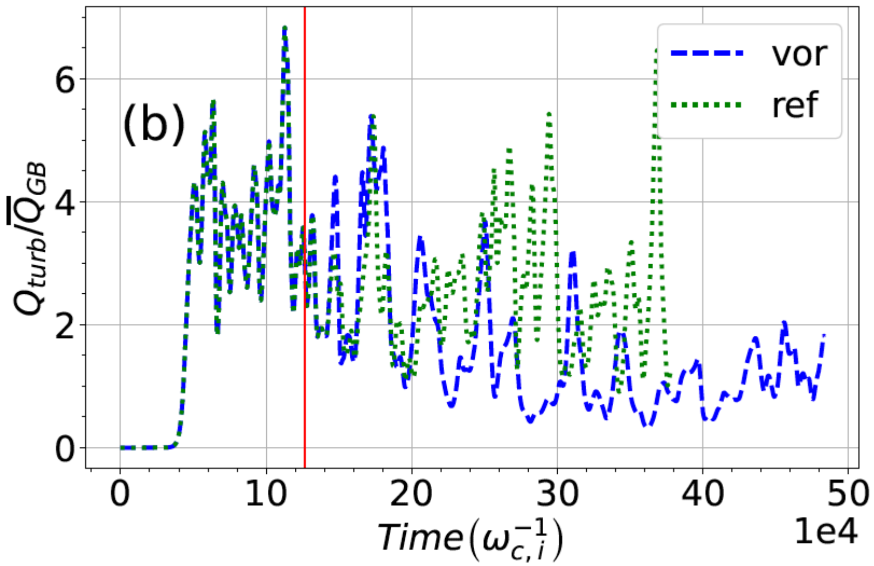
2. Vorticity source in GYSELA

vorticity source case

reference case





In the r/a = [0.7,0.8] region

Vorticity source region

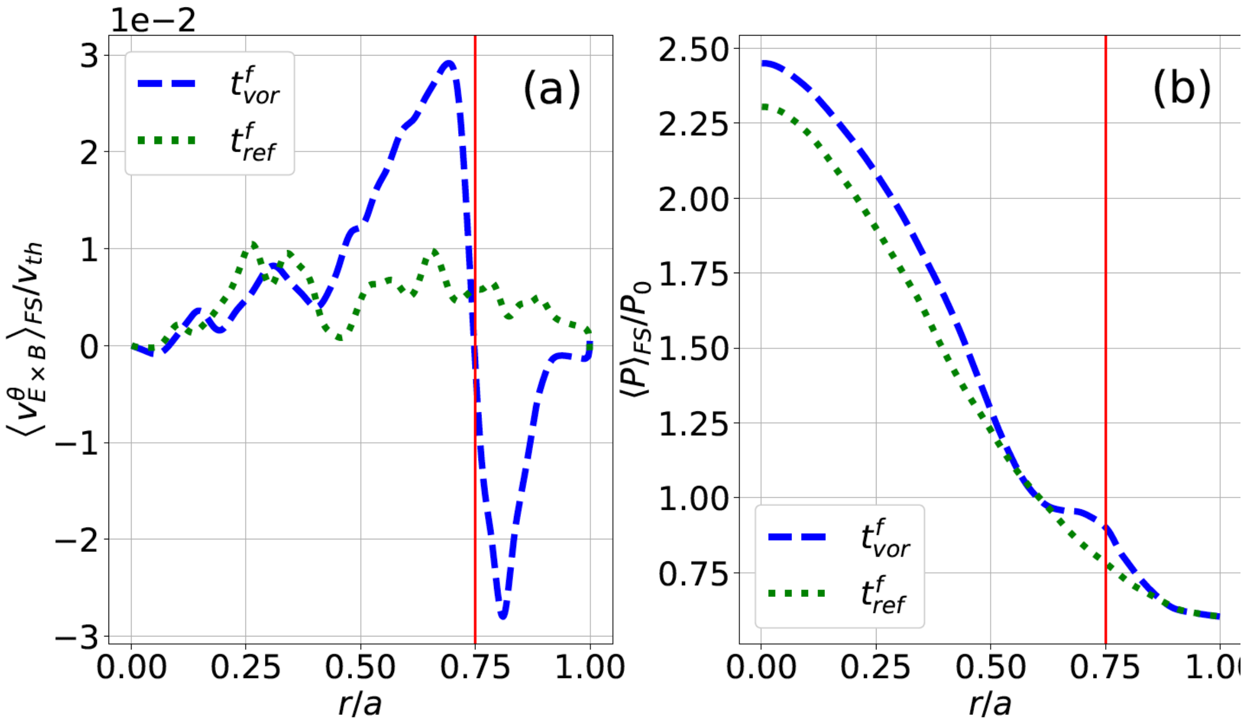
In the r/a = [0.4,0.5] region

Core region

2. Vorticity source in GYSELA

vorticity source case

reference case



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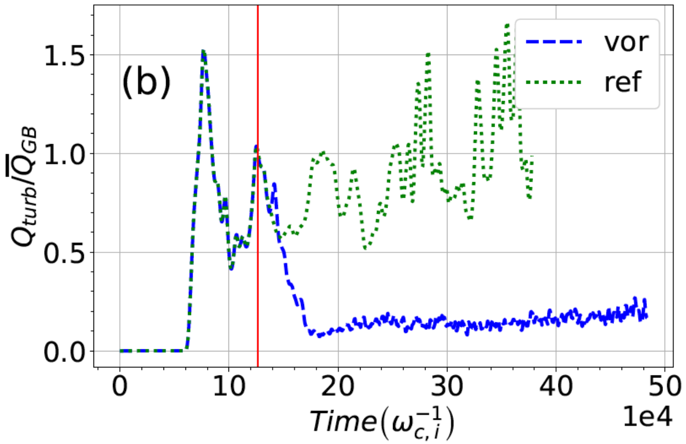
2. Vorticity source in GYSELA / Steep gradient case

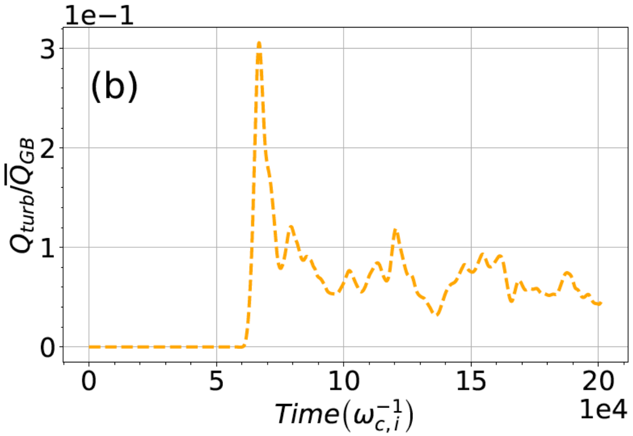
vorticity source case

$$\frac{\partial f}{\partial t} + \frac{1}{B_\parallel^*}\nabla_{\mathbf{r}}.\left(fB_\parallel^*\mathbf{v}_{GC}\right) + \frac{1}{B_\parallel^*}\frac{\partial}{\partial v_\parallel}\left(fB_\parallel^* v_\parallel\right) = \mathcal{C} + S$$



gradient case

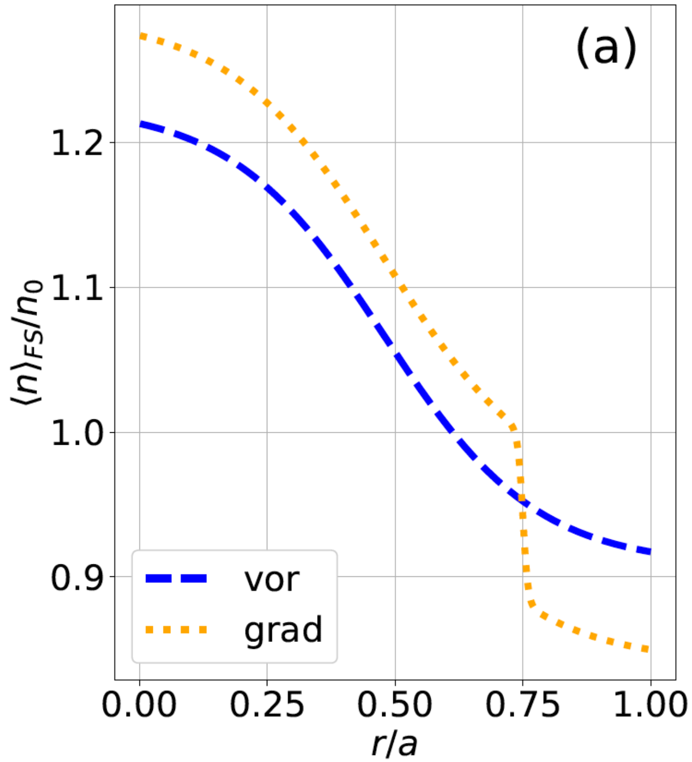
$$E_r = -\frac{1}{e_i n_i}\frac{\partial P_\perp}{\partial r} + v_\theta B_\varphi - v_\varphi B_\theta$$



Radial density profiles at t=0:

vorticity source case

gradient case



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2. Vorticity source in GYSELA

→ G. Lo-Cascio et al., Transport barrier in 5D gyrokinetic flux-driven simulations, submitted NF

Address how main ions and heavy impurities are transported across the transport barrier (Eurofusion TSVV#6)

Instabilité PVG (KH)

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3. Cylindrical geometry - SPEKTRE

→ **Develop a cylindrical version of GYSELA**

→ **Instabilities in SPEKTRE (ITG, KH)**

→ **Boundary conditions**

PhD 2022 ? (Grand-Est, IRFM, IJL)