Transport Benchmarking and Spheromak

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Outline

- Transport Tests
  - Introduction
  - Straight cylinder
  - Torus
- Spheromak computations

Transport Tests

• Many simulations of ICC experiments model the generation of the lowest-order fields.

• Most tokamak simulations have assumed that transport effects are much slower than the MHD activity and can be ignored.

• For slower MHD or lower temperatures, the two time-scales are not well separated.

• As we prepare for more comprehensive CDX-U computations (also recall old attempts at Pegasus), verifying basic properties such as classical and Pfirsch-Schlüter transport is important.

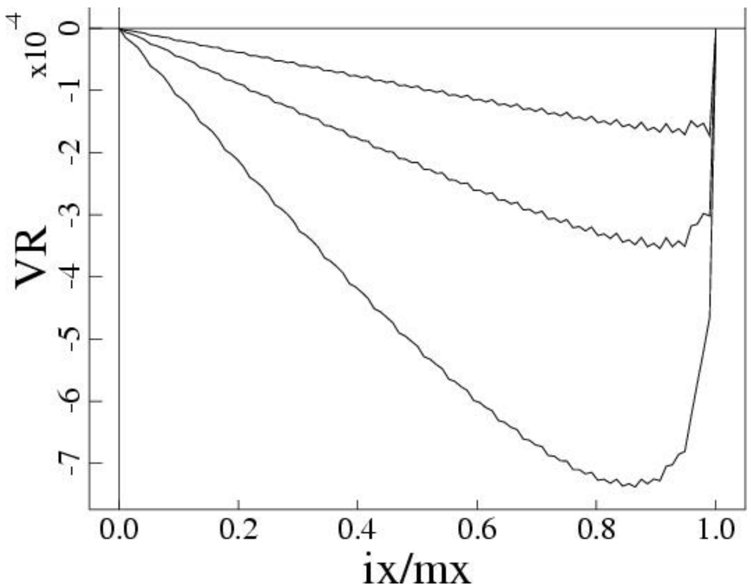
• John O'Bryan is running 2D cylindrical and circular cross-section toroidal tokamak with applied toroidal voltage to make these checks.

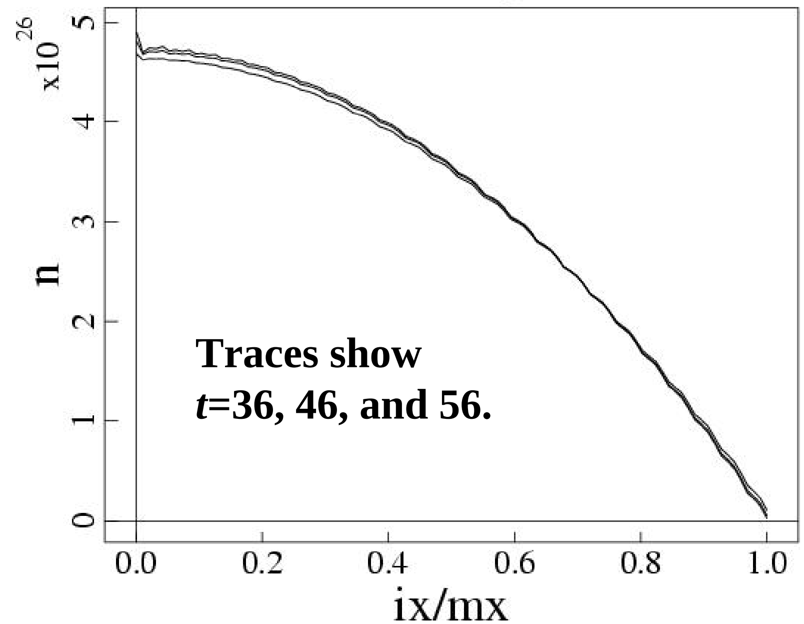
The cylindrical computations show a slow evolution after establishing the current profile.

• This computation has elecd=1, and E_{tor}=0.2 to generate B_{pol} that increases linearly to 0.1 at the wall. B_{tor}=1, and β=0.01.

• Number density is initially uniform.

• At t~1 (resistive time) the inward flow is ~10^{-2} (**E**×**B** drift).





• On a time-scale of 10-100 resistive times, the **E**×**B** drift vanishes as particle transport reaches its classical value.

$$\vec{\Gamma} = n\vec{v}_{\perp} = n\vec{v}_E - \frac{\eta \; p}{B^2}\nabla n$$

• Inward drift at $r(a)$ is set to 0.

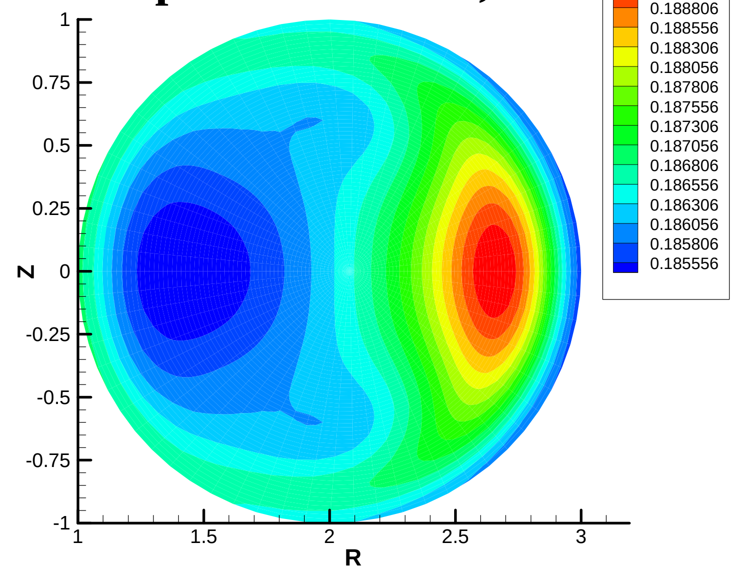
In toroidal geometry, resistive MHD should produce Pfirsch-Schlüter transport.

• Pfirsch-Schlüter current arises from force-balance in toroidal geometry.

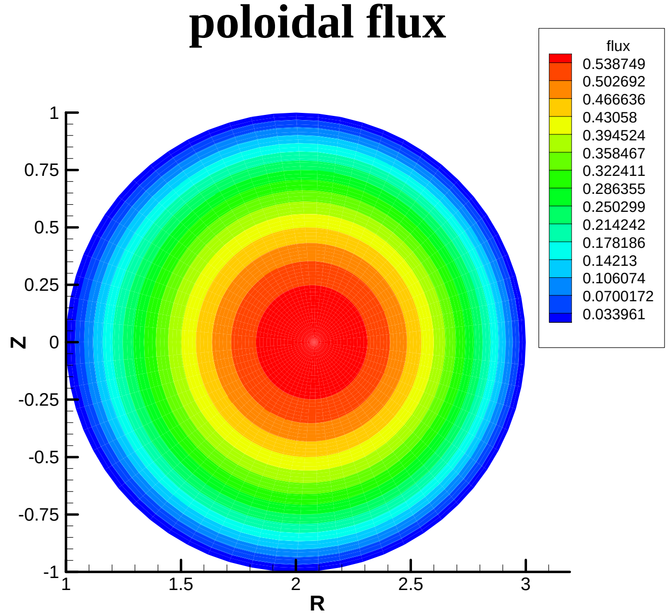
$$\lambda = -I' - \frac{\mu_0 I P'}{B^2}\,; \quad \lambda_{ps} = -\mu_0 I P' \left(\frac{1}{B^2} - \left\langle \frac{1}{B^2} \right\rangle \right)$$

• The variation in λ from computations is at least approximately correct--precise checks are needed.

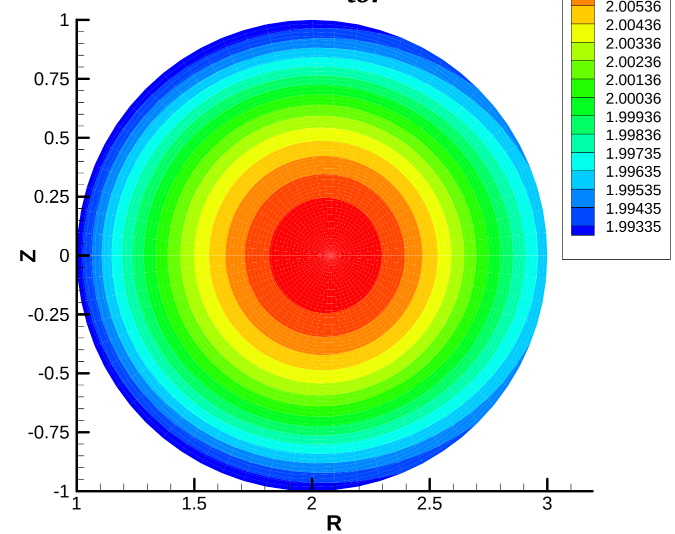
parallel current, λ



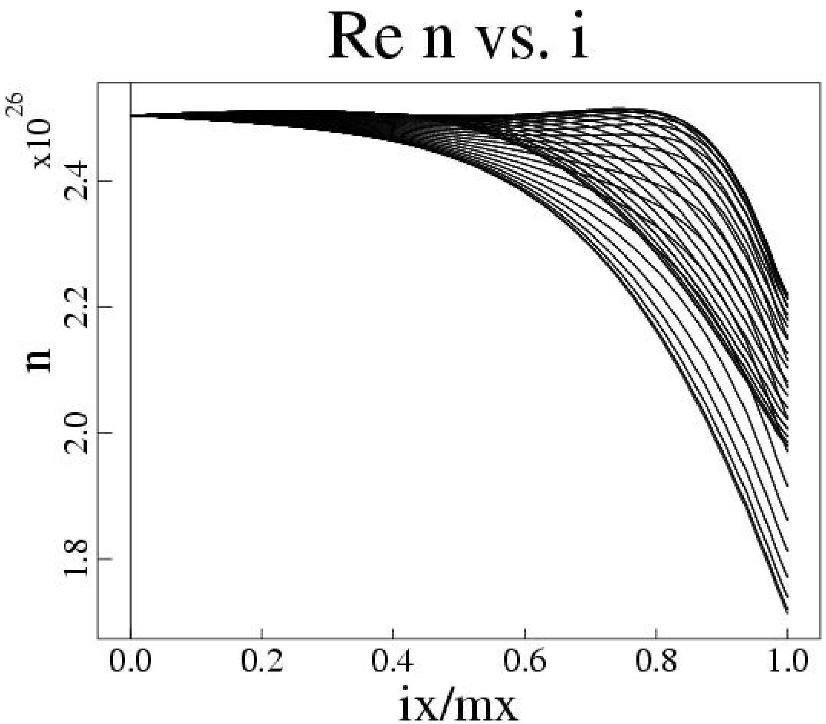
poloidal flux



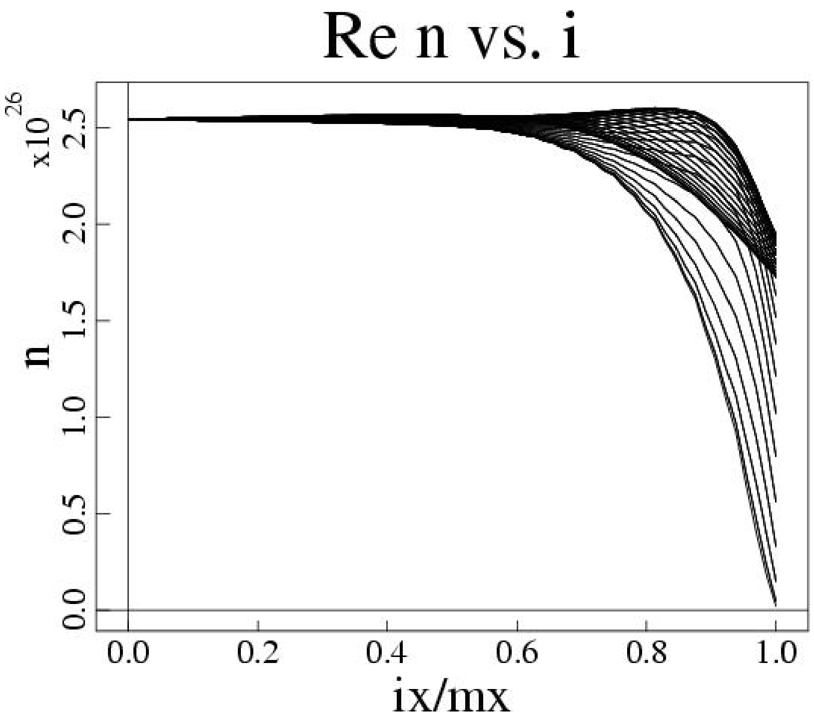
I=RB$_{tor}$



The number density on the inboard side tends to evacuate, and artificial particle diffusivity has been used.



Number density with nd_diff=10^{-2}.



Number density with nd_diff=10^{-4}.

• When verifying Pfirsch-Schlüter transport, we need to ensure that the artificial diffusion does not upset subtle balances.

Spheromak

• The LLNL group has found that MHD activity in the high-confinement stage of SSPX simulations is very sensitive to dissipation coefficients.

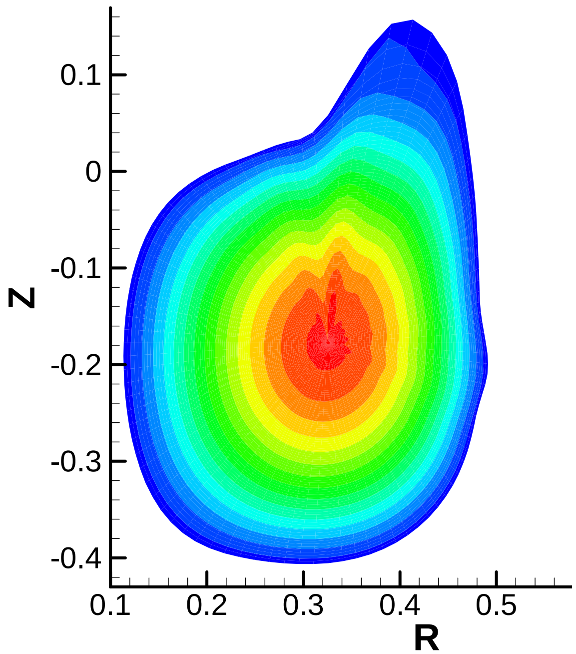
• The robust behavior in experiments suggests that other physics--possibly two-fluid--may keep activity at a low level.

• In a systematic approach to applying two-fluid modeling to spheromaks, Eric Howell is first testing linear behavior.

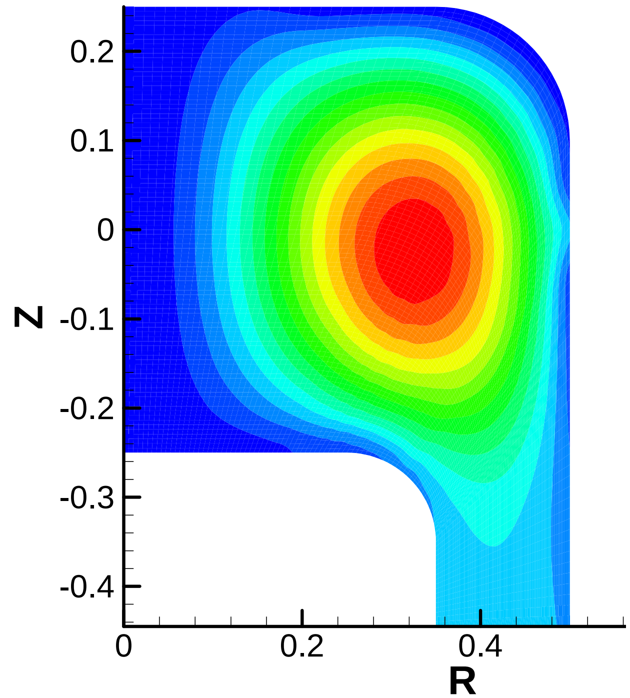
• The LLNL group has supplied Corsica equilibria generated from fits to SSPX data.

• The data is in two formats. One is standard EFIT that that FLUXGRID can mesh to the separatrix; the other is more global. Eric interpolates the latter onto the meshes used for nonlinear computations.

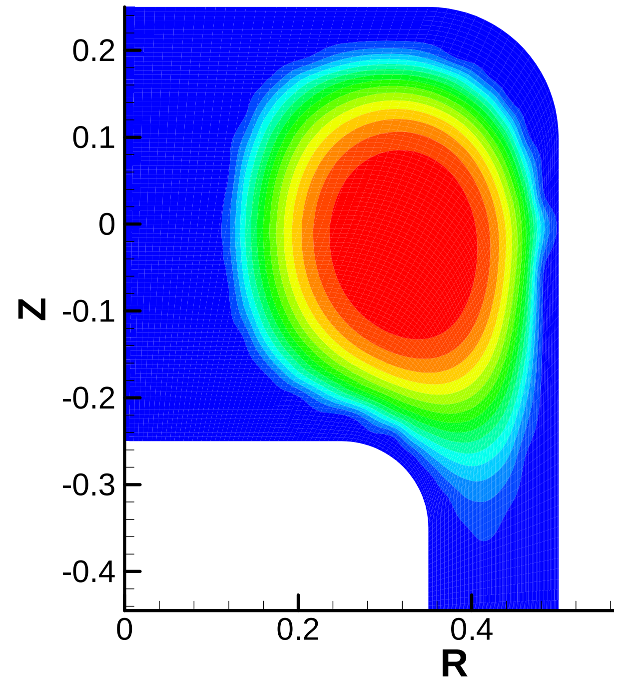
The equilibrium data is flipped onto the full-geometry mesh .



poloidal flux (fluxgrid)



poloidal flux



pressure

- The full-geometry interpolates using bicubic splines, and there are oscillations near the walls (not shown).

- We have not yet produced linearly growing modes with either distribution.