Some NSTX Transport Issues – from a View Point of Global Gyrokinetic Simulation

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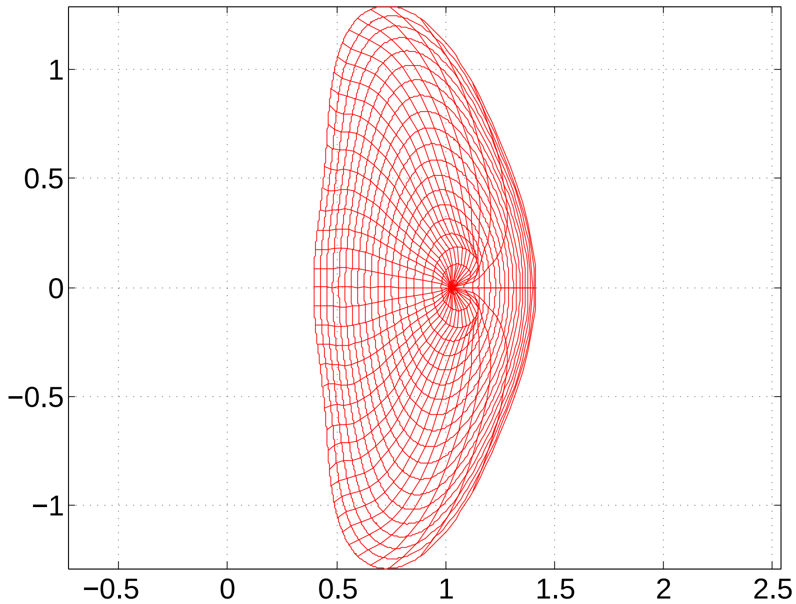
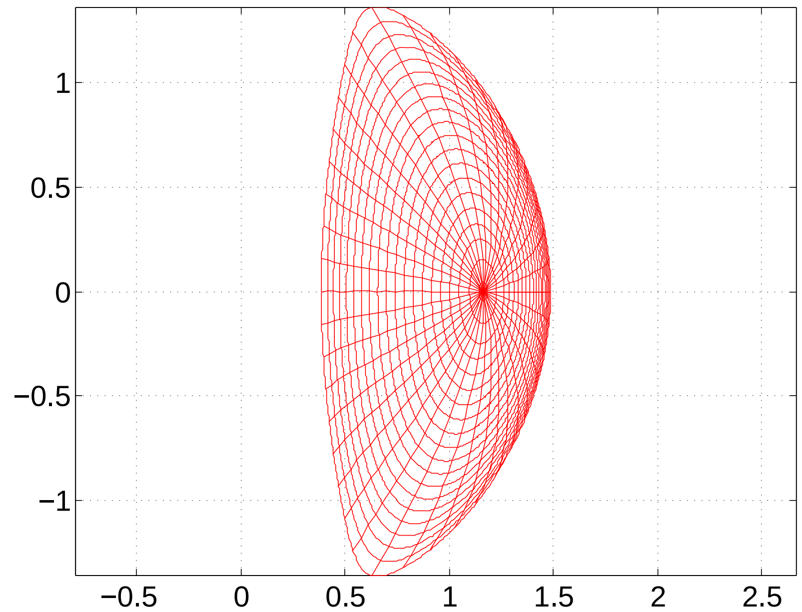
Some NSTX transport issues

- Global GK simulation of high-β, strongly-shaped NSTX-U can be highly challenging





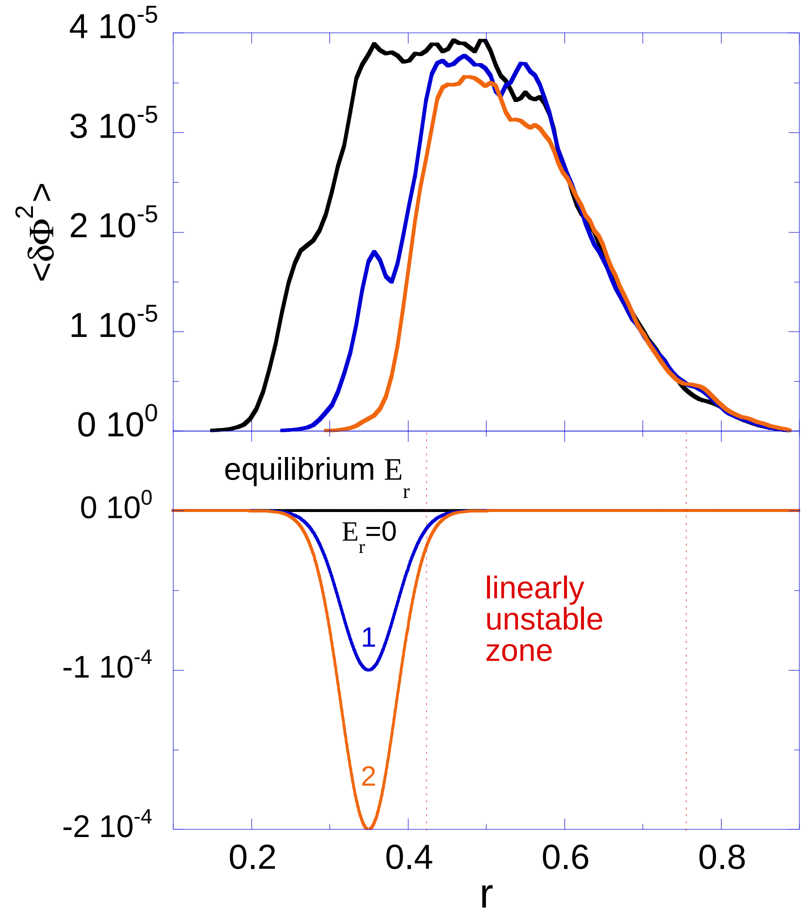
– Capability with efficiency and robustness needed to handle high-β, strongly-shaped NSTX-U plasmas

– A major upgrade/optimization of GTS is ongoing to remove difficulty

Turbulence spreading and control

- Turbulence spreading effect more pronounced in ST due to small machine size – particularly interesting for reversed magnetic shear plasmas

- Identify turbulence spreading in experiments
- Identify various effects on turbulence spreading, e.g.,
  - $\mathbf{E} \times \mathbf{B}$ shear layer
  - reversed magnetic shear
- Quantify in what extent NSTX-U transport and profile are influenced by turbulence spreading
- Explore possibility of creating a local $\mathbf{E} \times \mathbf{B}$ shear layer to decouple confinement core from strongly turbulent edge



Wang et al., PoP'07

Effects of turbulence induced energetic particle transport

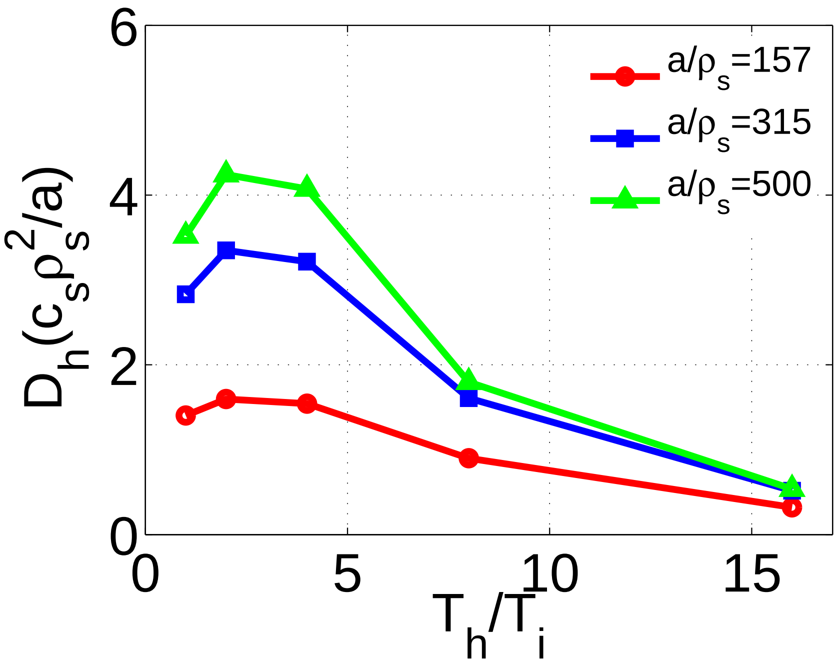
Understand possible consequence of turbulence-induced radial transport of energetic particles

- Both ITG and TEM can significantly enhance energetic particle transport

- Impact on toroidal rotation
  $\mathbf{J} \times \mathbf{B}$ torque associated with EP loss could be largely enhanced from small neoclassical level

- Impact on neutral beam current drive – current redistribution

- How big are these effects in ST?



Chowdhury, Wang, Ethier et al., PoP'12, etc

Momentum transport and rotation generation

- Strong asymmetry in χ_ϕ and χ_i in NSTX plasmas (Kaye et al., NF'09)

  – seems consistent with the story of residual turbulence driven transport (Wang et al., PRL'09)

  Prandtl number ($\equiv \chi_\phi/\chi_i$): $P_r^{\mathrm{turb}} \gg P_r^{\mathrm{NC}}$

- Which turbulence, e.g., ITG vs TEM, determines intrinsic rotation

- Scaling of intrinsic rotation in STs?

  ($\Delta V_\phi \sim \Delta W/I_p, \nabla T_i$ in tokamak H-mode)

  – relation between intrinsic rotation and electron parameters, q, dq/dr ...

- Momentum exchange and partition between bulk ions and impurities

  – only impurity's momentum measured, but large part maybe in bulk ions

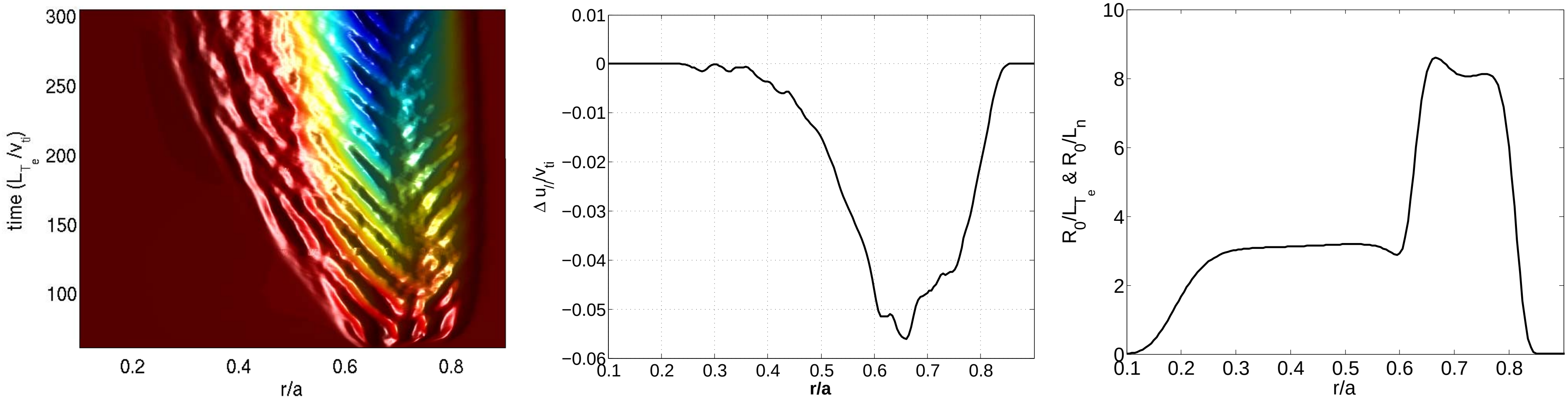
  – exchange via Coulomb collisions (neoclassical) and turbulence wave-particle interactions.

  – how momentum is conserved

  – asymmetric in turbulent torque for main ions and impurities?

Momentum transport and rotation generation

- Coupling of of core rotation to edge/pedestal flow/torque



– core-peaked rotation and edge-peaked intrinsic torque observed in expt.

– strong torque could be generated by turbulence residual stress at pedestal

– turbulence spreading and flow pinch may bring edge flow/torque into core

- Identify lowest order effect for intrinsic rotation generation
  e.g, up-down asymmetry vs. others (A. Boozer) – control algorithms?

Other transport issues

Non-inductive currents

- What can modify bootstrap current

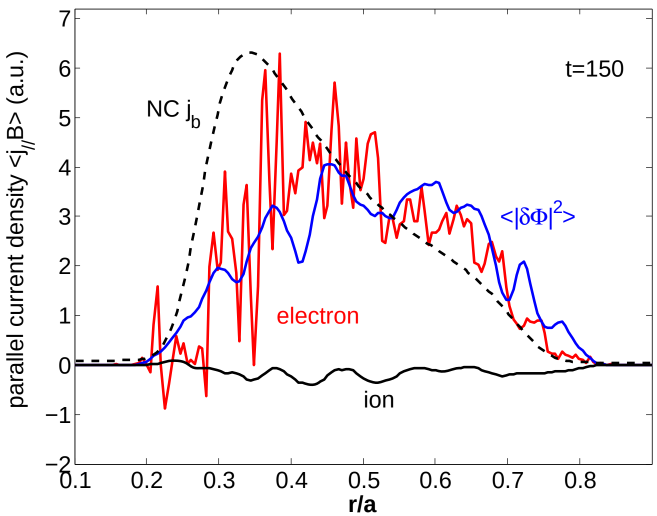
  – Strong plasma gradient at pedestal/ITB

  minor changes ($< 10\%$ when $\Delta_{\rm b} \sim L_{\rm p}$) according to GTC-NEO results (PoP'06) (seems reasonable because $J_{\rm bs}$ mainly carried by passing particles on which finite orbit effect is small)

  – Magnetic island, magnetic perturbations (poorly known)

- Possibility of turbulence generated current

  Identification: examine statistical trend of $(J^{\rm expt}_{\rm non-ind} - J_{\rm bs})$ using large expt. databases



Turbulence and neoclassical transport with magnetic island and 3D perturbations

MHD-turbulence interactions for island evolution ... (A. Reiman)