NSTX

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Simulation of microtearing turbulence in NSTX and scaling with collisionality

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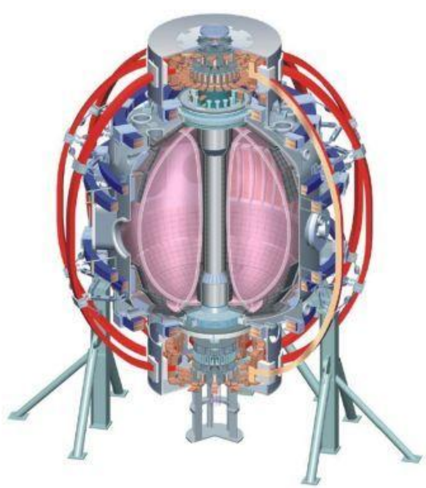

Outline of talk / Work done (follows TTF plenary talk)

- Experimental motivation: favourable $\Omega_i\tau_{E,th} \sim \nu_*^{-0.95}$ dependence in NSTX
  - Cause of anomalous χ_e in high-β discharges unknown, scaling to future devices uncertain
  - Microtearing modes unstable in high ν_* discharges (r/a≈0.5-0.8)
  - Linear stability scaling $\gamma_{lin} \sim \nu_e$ qualitatively consistent with experimental trend → motivates non-linear simulations using realistic experimental parameters

- First non-linear gyrokinetic microtearing simulations for NSTX (PRL, 2011)

  New and unique physics
  - Simulations require relatively fine radial grid to resolve resonant current layers (Δ_j~$0.3\rho_s$)
  - Significant transport ($\chi_{e,sim}\approx\chi_{e,exp}\approx 5m^2/s$), dominated (~98%) by magnetic flutter ($\delta B_r/B$~0.15%)
  - Perturbed field lines are globally stochastic ($w_{island}>\delta r_{rat}$), test particle stochastic transport model ($\chi_{st}\approx v_{Te}\cdot D_M$) agrees to within 25% of simulations

  Transport scaling relevant to experiment
  - Predicted $\chi_{e,sim}/\chi_{GB} \sim \nu_{*e}^{1.1}$ similar to experimental scaling
  - "Stiff" with ∇T_e , instability threshold important (apparent non-linear upshift)
  - Suppressible by experimental levels of E×B shear

  Measurement opportunities
  - BES ($k_\theta\rho_s<1$), high-k scattering (δn, $k_r>>k_\theta$), polarimetry (δB_r strong, broad & ballooning)

Additional work that could strengthen conclusions

- Summarize newer, more comprehensive linear scans
  - Generally, γ maximum around $Z_{eff} \cdot \nu_{ei}/\omega_{*e}$~1-5, complicates simple $\gamma_{lin} \sim \nu_{ei}$ interpretation
  - Finite thresholds in β_e, a/L_{Te}, also γ maximum around s/q~1.5
  - We can contrast scaling with ETG, especially differences in Z_{eff}, s/q
  - Highlight experimental range of $Z_{eff} \cdot \nu_{ei}/\omega_{*e}$, β_e, s/q etc… for ν_*, β, I_p, B_t scans

- Clarify influence of Δx in nonlinear ν_{ei} and ∇T_e scaling
  - Additional simulations at higher ν_{ei} to identify local maximum predicted linearly
  - Limited repeat of ν_{ei} scan at higher resolution (& with γ_E) – does $\chi_{e,sim}/\chi_{GB} \sim \nu_{*e}^{1.1}$ hold?
  - Apparent non-linear $(\nabla T_e)_{crit}$ upshift – possibly a consequence of sub-optimal resolution?

- Clarify influence of Z_{eff}>1 in nonlinear sims
  - Increasing Z_{eff} tends to destabilize microtearing and shifts γ maximum via $Z_{eff} \cdot \nu_{ei}$
  - Possibly OK to run simulations with reduced ion model (adiabatic, or one ion with $n_i/n_e = Z_{eff}$)

- Have also tried numerous simulations at other locations (r/a=0.5,0.65,0.7), so far without much success