PPPL PRINCETON PLASMA PHYSICS LABORATORY

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Validating electromagnetic effects on transport and turbulence in high performance plasmas

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NSTX-U / DIII-D Collaborative Research National Campaign 2017

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Motivation: Expecting EM effects to be important at high beta in NSTX-U; Can validate internal δB measurements now at DIII-D

- Two diagnostics sensitive to internal δB now available on DIII-D:
  - Cross polarization scattering (CPS, sensitive to local δB)
  - Radial interferometer-polarimeter (RIP, sensitive to line-integrated δB)

- UCLA planning to install and test CPS (δB) on NSTX-U to investigate magnetic turbulence and relation to confinement - **now is an ideal time to validate EM effects on transport and turbulence in high-performance discharges (i.e. sufficient β, β_N) in DIII-D**

- With a suitable choice of target discharge, can obtain a broad suite of measurements: DBS (δn), CPS (δB), CECE (δTe), BES, PCI, reflectometry
  - Many (all?) of these are now available simultaneously (e.g. δB-δn cross-phase)
  - Need appropriate n & B_T for DBS, CPS, CECE access

- Interesting EM effects generally fall under two categories:

1) EM stabilization of ITG/TEM, synergy with fast ions (shown to be important in numerous cases)
2) Attempt to destabilize EM modes like KBM, MTM (more relevant to NSTX-U)

Possible target discharges (Some level of GK analysis exists for #'s 1-3)

1. **ITER-like H-mode (focus of Holland IAEA; Howard MP)**
   - Is ITER relevant; focus on EM stabilization of ITG, synergistic effect with fast ions
   - Polarimeter data and validation effort would complement C-mod data from MP this past July
   - Would complement (or duplicate?) experiments from ROF

2. **QH mode, shown to have strong EM effects (Holland, NF 2012; Ernst PoP 2016)**
   - Targets established, good diagnostic access, strong ITG/TEM EM stabilization ρ~0.3
   - Many QH modes around ρ~0.6 exhibit linearly unstable MTM at low $k_\theta \rho_s$~0.2
   - Near axis (ρ~0.3), QH can be near KBM threshold (Ernst, ROF 140)
   - BUT, would largely be repeating shots just for new CPS, RIP diagnostic data

3. **High β_{pol}, high q_{min}, non-inductive discharges (DIII-D/EAST work, Garafolo et al)**
   - High beta, strong influence of EM and flow shear effects
   - Overlaps with non-inductive scenario development
   - Staebler thinks ETG could be very important (similar to NSTX)

4. **Lower field, NSTX-like shot ($B_T \leq 1$ T, Burrell, Bell poloidal CHERS MP; Podesta TAE identity MP)**
   - Problems with locked modes, AEs, low field removes CECE access

- Some cases from (2) & (3) exhibit neoclassical ion transport but anomalous electron transport, and GK analysis indicates presence of more exotic EM modes (KBM, MTM) – similar to ST H-mode transport characteristics

General approach

- Establish target, acquire all turbulence data

- Do one or more of following:

1) Add steady ECH (increase T_e, ∇T_e in attempt to drive MTM)

2) Add modulated ECH (looking for stiff behavior, or onset of MTM, correlation between modulated ∇T_e and turbulence characteristics)

3) Modulate NBI (similar to 2, looking for onset of deep core KBM, dynamic change of turbulence characteristics)

4) Parameter scan (B_T, n, P, ν, β) – scaling of δB correlated with changes in transport & confinement