NSTX

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T&T TSG Theory Brainstorming Topic Discussion

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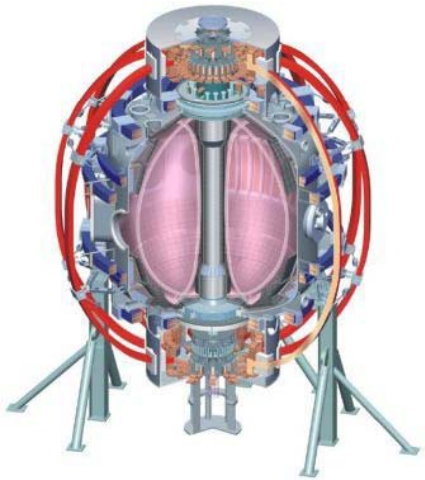

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Goals of the Meeting

- Gather ideas for the upcoming theory brainstorming
  - Theories/ models experimentalists want
  - Experiments theorists want

Two Thrusts and Three Radial Regions Identified for the 5-year Plan

- Two thrusts for the 5-year plan
  - Identify instabilities responsible for anomalous electron thermal, momentum, and particle/impurity transport in L and H mode plasmas
  - Establish and validate reduced transport models (0D and 1D) for NSTX-Upgrade plasmas
- Three spatial regions of concern in NBI H-modes relevant to NSTX-U and beyond
  - Core gradient region (r/a~0.4-0.9) – inside pedestal where significant gradients in thermal plasma exist (→microinstabilities predicted unstable) (also applies to L-mode plasmas)
  - Core flat region (r/a<~0.4) – approaching magnetic axis where thermal gradients become small (→microinstabilities predicted stable) but significant fast ion pressure ($P_{fast}/P_{tot} \leq 50\%$) (Alfvenic modes important) and turbulence spreading from r/a>0.4 may also be important
  - Pedestal (r/a>0.9) - pedestal height plays an important role in global H-mode confinement (BP TSG)

Overview of Tasks of the Two Thrusts

- Identify instabilities responsible for anomalous transport (thermal, momentum, and particle/impurity)
  - Focus on most relevant scenarios: low ν^* H-mode plasmas; fully non-inductive plasma; ITER-relevant plasmas
  - Measure scaling of local transport (χ_e, χ_φ, D_d, D_c) with relevant parameters (ν_e, I_p, B_T, γ_E, s, q, …)
    - Steady state analysis and perturbative experiments
  - Measure turbulence characteristics (δn_e, δB_r, …) and scaling with parameters
    - k_θ spectra (k_r~0) highest priority, most relatable to transport
    - Multi-scale spectrum of modes possible ($k_\theta \rho_s$=0.1-20+), would like complete k-space coverage
    - Focus on parameter regimes where instabilities are expected to be isolated
      - Use 2nd NB and 3D field coils as controlling tools
  - Compare with linear and non-linear predictions to discriminate theoretical modes
    - k spectra (coupled with synthetic diagnostics) and transport fluxes
- Establish and validate reduced transport models for NSTX-Upgrade plasmas
  - Explore 0D confinement scalings (ν_e, β_e, I_p, B_T, …) in NSTX-Upgrade parameter regime: higher Bt, Ip and lower ν^* and project to FNSF/Pilot
  - Develop profile database for most relevant scenarios
  - Focus on developing reduced transport model for ion thermal transport
    - Reduced model, e.g. TGLF, against gyrokinetics for NSTX/NSTX-U parameters for low-k turbulence
    - Validating neoclassical transport models (pretty good prediction just using Chang-Hinton model for some NSTX shots)
  - Validate reduced ion thermal transport model for NSTX/NSTX-U/MAST
  - Will attempt to develop electron thermal transport model
    - Start with analytic fits to linear and non-linear GK simulations (*e.g.* IFS-PPPL for ITG) for μ-tearing and ETG
    - Reduced model against gyrokinetics for NSTX/NSTX-U parameters for μ-tearing and ETG

Draft Topics on Theory/Modeling Needs (I)

- Develop a suite of synthetic diagnostics integrated with numerical codes
  - To facilitate turbulence measurement and theory/simulation comparison
    - Identify instabilities
    - Validate theories/models
  - To assist further diagnostic development
  - BES, High-k scattering, PCI, reflectometry, polaritmetry and edge magnetic pick-up coils

- Develop interpretative and predictive capability for H-mode pedestal (r/a>0.9)
  - Empirical/semi-empirical scaling of pedestal height & width with "engineering" parameters (I_p, B_T, n_e, Z_{eff}) and/or theory parameters (ν^*, β, ρ^*)
  - Development and validation of pedestal height models with data (EPED1, any others)
  - Pedestal turbulence (Local and global gyrokinetic, fluid codes, e.g. GYRO, XGC, BOUT++, GTS)
  - Predict microstability (KBM,…) thresholds in pedestal (linear gyrokinetics, any others)

Draft Topics on Theory/Modeling Needs (II)

- Develop interpretative and predictive capability for NBI-heated H-mode core-flat region (r/a<~0.4)
  - Empirical/semi-empirical scaling of core T_e profile flattening with fast ion population, gradient, β_{fast}, etc…
  - Simulations of fast particle driven instabilities and associated transport
  - Development of reduced models (theory, semi-empirical, etc…) of χ_e, χ_ϕ and $D_{j||}$ for use in predictive simulations
  - The effect of turbulence spreading from H-Mode core gradient region (r/a~0.4-0.9)

- Develop interpretative and predictive capability for H-Mode core gradient region (r/a~0.4-0.9)
  - Identify1D profile database for model validation from relevant discharges from NSTX/U
  - Test TGLF (or develop other reduced models) against linear and nonlinear gyrokinetics for NSTX-relevant parameters, especially for ETG and/or micro-tearing dominant regimes
  - Develop reduced models with global effects
  - May need global, multi-scale simulations due to large profile variations
  - Reconcile anomalous electron and momentum transport with neoclassical ion transport