U.S. DEPARTMENT OF ENERGY | Office of Science

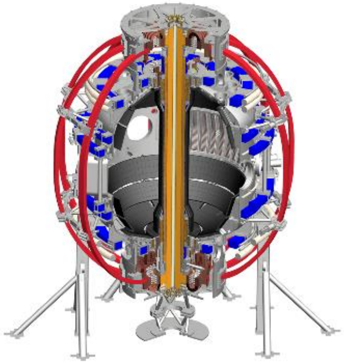
NSTX-U

NSTX-U Milestone R(18-3) update

T&T TSG group meeting

December 7, 2017

PPPL



Agenda

- Summary of milestone tasks (Guttenfelder)

- TGLF model choices & recommended defaults (Staebler)
- Status of TGLF-GYRO L-mode comparison (Guttenfelder, Staebler)

- Status of TRANSP profile predictions (Kaye)
- Status of TGYRO-TGLF profile predictions (Grierson, Guttenfelder)

- Discussion of EFIT Uncertainty Quantification (Grierson, Sabbagh)

<u>Future</u> (~ Jan 4, 2018?)

- Summarize MTM model, comparisons with GK (Rafiq)

R18-3: "Validate and further develop reduced transport models for electron thermal transport in ST plasmas"

- **Focus of the milestone is on core electron thermal transport (ρ~0.4-0.9)**
  - **Main goal is to predict Te profiles from pedestal top inwards**
  - Not modeling the H-mode pedestal
  - Not modeling GAE/CAE-KAW mechanisms near-axis
  - Not focusing on turbulence measurement/validation

- **Three complementary parts of milestone activities**
  1. **Model validation (how well does model predict experimental Te)**
  2. **Model qualification (how well does model recover GK predictions)**
  3. **Analysis (Revisit profile fitting & mapping, EFIT reconstructions → Uncertainty Quantification)**

- **Considering multiple theoretical mechanisms in multiple regions of operating space**
  1. High-β, high-ν → MTM thought important
  2. High-β, low-ν → does NC + KBM set the limit on T_i & T_e?
  3. Low-β → expecting traditional electrostatic ITG/TEM at low aspect ratio
  4. When and where does ETG (electron-scale) fit in for all the above?

Outline of milestone tasks

- **Model validation (how well do profile predictions recover exp.)**
  [V1] H-mode profile predictions using TGLF, Rafiq-MTM, RLW
  [V2] L-mode profile predictions using TGLF, MMM
  [V3] Identify cases where ETG provides non-negligible Q_e (L & H mode)
  [V4] Develop and implement algorithm for locally constrained KBM profiles

- **Model qualification (how well do models recover linear & nonlinear GK)**
  [Q1] MTM: Document TGLF & Rafiq-MTM linear & nonlinear with gyrokinetics
  [Q2] ITG/TEM: Document linear stability, nonlinear saturation dependencies with aspect ratio
  [Q3] ETG: Do TGLF and MMM recover GK NL ETG predictions?
  [Q4] KBM: Document TGLF α_{crit} with linear GK
  [Q5] ITG/TEM: Document non-local deviations from local GK, use to inform local models
  [Q6] DTEM: Benchmark local GK codes with global GK for DTEM conditions

- **Analysis (profile fitting & mapping, EFIT reconstructions)**
  [A1] Revisit EFIT w/ Pfast, rotation… influence on GK stability, thresholds

Outline of milestone tasks & estimated quarterly timeline (Q1-Q2, Q2-Q3, Q3-Q4)

- **Model validation (how well do profile predictions recover exp.)**
  - **[V1]** H-mode profile predictions using TGLF, Rafiq-MTM, RLW
  - **[V2]** L-mode profile predictions using TGLF, MMM
  - **[V3]** Identify cases where ETG provides non-negligible Q_e (L & H mode)
  - **[V4]** Develop and implement algorithm for locally constrained KBM profiles

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  - **[Q1]** MTM: Document TGLF & Rafiq-MTM linear & nonlinear with gyrokinetics
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General predictive transport simulation methodology & concerns

- Transport predictions solve 1D transport equations to predict $T_e(r)$ or $T_e(r,t)$

$$\frac{3}{2} n_e \frac{\partial T_e}{\partial t} + \langle \nabla \cdot Q_e \rangle = P_{NBI,e} + P_{RF,e} + Q_{ie} - P_{rad}$$

- We are testing transport models that provide flux-gradient relationships

Transport model

$$\begin{bmatrix} \Gamma \\ \Pi_\varphi \\ Q_i \\ Q_e \end{bmatrix} = -\begin{bmatrix} \text{flux} - \text{gradient} \\ \text{relationship} \\ \text{matrix} \end{bmatrix} \cdot \begin{bmatrix} \nabla n \\ R\nabla\Omega \\ \nabla T_i \\ \nabla T_e \end{bmatrix}$$

- **We must always state assumptions, model choices, & boundary conditions, e.g.**
  1. **Only predicting T_e (holding n_e, n_d, n_c, T_i, n_{fast}, T_{fast} & Ω fixed)**
  2. **Using time-dependent TRANSP (or TGYRO at one time-slice)**
  3. **Evolving sources, sinks and electron-ion energy-exchange**
  4. **Using TGLF transport model (sat1, updated Ampere's law)**
  5. **Boundary Conditions: measured T_e at ρ=0.8 + zero flux condition on-axis**