Status and plans for Joint Experiment EP-8

Validation of Neutral Beam Current Drive and projections to ITER

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20th ITPA Topical Group on Energetic Particles
ITER HQ, Cadarache - France
September 23-25, 2018
Goals of JEX EP-8

• Assess NB-CD efficiency vs. NBI parameters
  – Include conditions for which EP behavior departs from ‘classical’

• Develop/validate modeling tools to predict NB-CD in future devices (ITER and DEMO)
  – Include tools to account for ‘non-classical’ effects
  – Consider enhanced EP transport by instabilities, microturbulence
Progress in last ~6 months: extending modeling tools to low-f instabilities

- NSTX/NSTX-U
    • Goal: improve sawtooth model in TRANSP
  - Started dedicated activity on NTM, fishbone, kink modeling [Podestà US TTF 2018]
    • Goal: develop “self-contained” module for TRANSP
  - Progress in development, benchmark of Quasi-Linear model RBQ1D

- DIII-D
  - Progress in diagnostics (see M. VanZeeland’s talk)
  - Recent experiment on “AE mitigation in high-q_{min} discharges”
    • Goal: explore mitigation/suppression techniques
    • Assess predictive capabilities of reduced EP transport models (US JRT 2018)
    • Analysis started
  - Progress in validating “kick model” for NTMs [Heidbrink, IAEA-EP 2017] [Heidbrink, US TTF 2018] [Bardoczi, US TTF 2018]
    • Goal: develop self-contained module for TRANSP
Progress in last ~6 months: New experiments, analysis ongoing

**ASDEX-U/TCV (MST1 programme)**
- High-$q_{\text{min}}$ scenarios with high NI fraction on AUG
- Preliminary results: good agreement between measured & simulated MSE, Vloop
  - Neoclassical, in spite of strong MHD activity,
- However: enhanced EP transport required to match neutrons, $W_{\text{mhd}}$, FIDA
  - Results in disagreement for MSE, current!
- See B. Geiger’s presentation

**MAST-U**: plans unchanged from previous meeting
- Experimental programme coordinated within EU-MST1
- *Fast Ions and Current Drive* studies are prominent part of it
Progress in last ~6 months: Experimental data available, modeling tools needed

• TJ-II
  – Database on NBCD available from past years
  – No new experiments in last ~year (fixing technical issues)
  – Analysis of experimental data starting
  – Main issue: lack of modeling tools!
    • Need to improve maturity of modeling tools for NBCD to same level as those available for axi-symmetric configurations
Coordinated NSTX-U/DIII-D effort has started to understand & model EP transport by NTMs

Ongoing validation of “kick model” with NTMs (L. Bardoczi, DIII-D)

Goal: predictive model for EP transport by NTMs

Leverage work by Poli & Fredrickson to include NTM stability model in TRANSP
Example: interpretive TRANSP analysis, no free parameters

- NTM island width from measurements
- Reproduce neutron rate, stored energy

- NB current redistribution depends on NTM spectrum
  - e.g. core peaking vs broadening predicted for 2/1 vs 3/2 NTMs

(L. Bardoczi, DIII-D – US TTF 2018)
Plans

- Applying new modeling tools for EP transport by low-f instabilities
  - Assess resulting NBCD degradation
  - Assess synergy between low-f modes and AEs

- Working to make modeling tools (*kick model*) available to broader community

- Assessment of predictive capabilities would benefit from coordination with ITPA IOS
  - Joint meeting in the near future (1 day overlap)?

- **Need quantitative NBCD modeling tools for non-axisymmetric configurations!**
Continuous progress in NB-CD database and analysis tools

- NSTX/NSTX-U/DIII-D
  - Database on NB-CD expanded
  - Focusing on identification of “critical parameters” for reliable, quantitative CD predictions

- ASDEX-Upgrade, TCV
  - Progress in experiments with MSE, FIDA data with NBI
  - Analyzing discharges with high non-inductive current fraction, look for effects of instabilities on NB-CD performance

Converging to similar methodology:

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experiments    constrained simulations    predictions
NSTX/NSTX-U     DIII-D                      AUG/TCV
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Comparison with exp’t data
Open issue: relax constraints in TRANSP simulation degrades prediction accuracy

- Remove additional constraints in TRANSP simulations, check agreement with “reference” run
  - Unconstrained $V_{\text{surf}}$ leads to similar NB-driven current profile, but “large” discrepancy in predicted q-profile
    - Ongoing work: assess role of computed resistivity [F. M. Poli, D. Kim]

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**Graph:**
- Classical – input equ
- Classical – predict equ/2
- Kick model – input equ
- Kick model – predict equ/2

**Graph Details:**
- $J_{\text{nb}}$ [kA/m²]
- q-profile
- Toroidal flux