**PAC-37 Report: Core Science Group**

* Experimental plan comprehensive and coherently structured
* Agree with priorities
* Well-aligned with FESAC/FES initiatives, and includes important ITER-relevant research
* Link with Theory strengthens research

Transport and Turbulence

Observations

* Organization around multi-TSG XPs is very effective

Recommendations

* Priority should be given to XPs that can lead to achievement of long-term goals (in context of high-Z walls)
  + Impact of rotation on relative role of neoclassical and turbulent high-Z transport
  + Impact of HHFW on high-Z transport (krypton, xenon more appropriate than neon)
    - Xenon/Krypton seeding XP idea in ResFor (Reinke) – might want to increase priority of this idea (late-run XMP?) – inform decisions about future high-Z upgrades
    - Prioritize ideas according to diagnostic availability, auxiliary systems (3D field pacing, pellet pacing), but make it simple initially (change rotation re 3D fields, NB); deeper in FY17
    - Diagnostics needed:
      * Basic core radiation (AXUV from Kevin/Luis) and LLNL spectroscopy for XMP; late FY16
      * More extensive absolute radiation diags (core bolometry, LLNL spectroscopy, JHU TGS and possibly XICS) for comparison to modeling – FY17, combine with LBO

Theory partnership

* Simultaneous application of PPPL and non-PPPL codes (e.g., GTS & GYRO) for validation
  + Comparison of multiple codes (GTS, GYRO, XGC-1) began in 2014 with residual stress momentum transport calculations (reported in PAC-35). A high priority effort this year will be multi-code gyrokinetic analysis of NSTX-U L-mode plasma for code verification and validation of heat, particle and momentum fluxes and low-k turbulence (2-3 dedicated XP/XMPs). We have also recently started GTS & GYRO simulation efforts for MAST as part of collaborative work with CCFE that is preceding the NSTX-U analysis (Walter, Weixing, C.S.)
* Development of synthetic diagnostics for direct comparison with fluctuation measurements (in particular, low-k: BES, reflectometry)
  + Diagnosticians work with Theory (Dave Smith/F. Poli/W. Wang)
  + Synthetic diagnostic for reflectometer has been done in EP (Crocker, Belova, Fredrickson, et al.)
  + High-k (ETG) synthetic diagnostic development of FP being passed onto A. White grad student

Macrostability

Observations

* NSTX-U remains at forefront of Macro studies
* Flexibility in MGI is world leading: should be given highest priority within TSG due to near-term timescales for providing input to ITER

Recommendations

* Add more run time to MGI experiments
  + TSG to relook at day allocation, work with RC to adjust
    - XMP will help, maybe additional reserve days
    - Piggybacking once the XP is run? Effect on next shot, etc. needs to be considered
  + Radiation measurements for MGI needed (a la C-Mod); radiation asymmetry, etc.
    - Not in plans concretely, so probably not show up before FY17-18; need planning now even for that
* Add word “stability” to R16-1 or R16-3 to acknowledge and justify large fraction of run time for this TSG
  + Passed unanimously
* Consider formation of Working Group to assess stability at wide range of rotation; includes development of modeling capability for equilibrium and stability at high flow
  + Ian Chapman interest
  + Rotation in equilibrium calcs (ISOLVER, EFIT, LRDFIT), in stability (MISK, etc);
  + Many experiments testing effects of rotation
  + Modeling capability development (Park, Ferraro, Jardin, ZWang,…) an opportunity – to discuss and coordinate
  + Probably do not need a formal WG
* Think in advance about how high-Z walls will affect Macro program in future
  + Incorporate high-Z impurity measurements into DECAF
    - Need to show some progress in algorithm development coupled to experimental plans
    - Can show correlation between disruptions and radiation power levels; can do in one year (SAS), assuming diagnostics available
    - Diagnostic availability will drive DECAF algorithms
    - Need LLNL spectroscopy + AXUV diodes (& bolometers) needed for this
  + Access to high-beta w/o mode control when islands can lead to impurity accumulation
    - Need to assess importance of NTM in NSTX-U through expt (LaHaye), and go from there (rotation control)?
    - Delgado XP (Priority 1) – “Stabilization of radiated-induced tearing modes (RiTMs) using off-axis-heating”
    - Use resistive DCON when ready – new capability

Theory partnership

* Maintain close relationship with Theory
  + Great idea

Energetic Particles

Observations

* Flexibility in NBI will enable a broad capability for tailoring the fast ion distribution
* Alfvén Eigenmode control potentially very high impact for ITER
  + Source 2 injection, even if degraded, suppresses CAE/GAEs – observation
  + Need to study stability boundaries, effects of RF and 3D in Upgrade

Recommendations

* Want update and status of TAEA at next PAC
  + Eric will make it work, once we get engineers and techs, etc. If not, next year we will be where we are this year. Not good if so

Theory partnership

* Provide vision to fully model AE evolution to validate against NSTX-U data and reliably extrapolate to ITER and FNSF-ST
  + Short-term: Improvements to ORBIT (saturation levels of modes – new feature, along with drive. Still needs NOVA input), improvements to NOVA (estimate parameter range for chirping vs stationary modes, other mode behavior), kick/CGM in TRANSP, new model by Gorelenkov w/o NOVA, CAE/GAE: HYM/reflectometer validation and modeling
  + Want also to develop longer-term plan
* Can M3D-K capture nonlinear WPI, collisional damping or fast ion orbit widths?
  + Response from Fu
    - Yes, M3D-K can capture nonlinear WPI and fast ion orbit (via gyrokinetic model). We plan to update M3D-K to full beam ion orbit in order to be more accurate for NSTX parameters.
    - Right now M3D-K has damping mechanisms of continuum damping and thermal ion Landau damping, but not collisional damping or radiative damping. These two dampings can be added if there is sufficient manpower
    - Thus M3D-K can model nonlinear physics of beam-driven AE, but the damping physics needs to be improved in order to model stability threshold more accurately.
    - Physics of damping in ST parameter range in NOVA also need improvement
  + In addition to Fu contribution two longer-term directions are being pursued (Gorelenkov):
    - GTS is being adopted to EP needs via MPP-PPPL center (Wange, Schneller) with short-term task to model eGAMs
    - Reduced models to be incorporated into NOVA-K/LBQ framework. In the short-term a 1D version of LBQ is being developed for future integration into TRANSP code with further detailed validation goals on various machines.
    - Both directions are long-term projects.
    - In general theory plans are correlated with the NSTX program and depend on it for validations and motivations.

Long-Term Upgrades/Plan (Core)

Observations

* Plan to control high-Z with ELMS may be insufficient (consider in terms of present HHFW and future RF capability)
* NCC significant for Macro (and other) research: finalize design asap
  + Design almost complete
  + Reduction in rotation may help with impurities, but negatively impact confinement
    - Fine control of 3D spectrum (with comprehensive set of coils) can lead to “fine” control of rotation and effects on turbulence and transport, MHD?

Recommendations

* Consider how long-term program requires capabilities by each of the proposed facility enhancements
  + NCC clear, high-Z not clear (NCC controllable, high-Z is not)
    - Issues are: how can high-Z help research, but also, how can we live with high-Z
    - Initially, we will assess high-Z effects, as well as specific areas
      * High-Z influence on disruptions, NTMs
      * High-Z impurity transport
      * Plans for mitigation follow assessment
    - Program issue, not just Core

Theory partnership

* A 5/10 year plan for how the Partnership will develop to ensure future impact on the NSTX-U program would be beneficial
  + SK to work with AB
  + Consider meeting of Core Group with relevant PPPL Theory and others to develop long-term plan for theory work, coordinated among all theory efforts
    - How is PPPL Theory plans impacted or complemented by non-PPPL theory work? Want to coordinate