NSTX-U

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R 19-X: Validation of Non-Axisymmetric Plasma Response Modeling to Address Compatibility with Core and Edge Constraints

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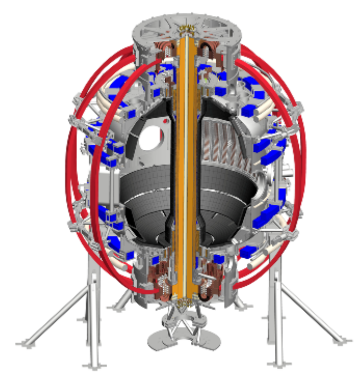

Core-Edge Compatibility Required for 3D Coil Designs

- For RMPs to be a reliable tool, we must tune them to do what we want and not what we don't
  - ELM suppression, density control, rotation shear, feedback stabilization
  - Rotation braking, locked modes, footprint splitting
- 3D fields could exacerbate heat flux concerns in NSTX-U
  - Fields change pitch angle
- Advanced divertor configurations may be more susceptible to problems due to 3D fields
  - Low Bp solutions (snowflake) → larger field-line excursions
  - Closed divertors (SAS, Super-X) → low tolerance for field-line excursions
- On DIII-D Low-Torque ITER baseline scenario (IBS)
  - ELM suppression doesn't work
  - Mode locking is ... frequent

Milestone: Apply Modeling to New Scenarios / New Geometries for Validation

- Use ideal / resistive / two-fluid models for calculating plasma response (e.g. IPEC, GPEC, MARS, M3D-C1)

- Model plasma response in NSTX-U, MAST-U, DIII-D, KSTAR

- Model discharges with new divertor geometries to assess compatibility with RMPs
  - NSTX-U high-performance scenarios
  - DIII-D SAS, MAST-U Super-X

- Provide perturbed fields for heat flux analysis (EMC3-EIRENE)

- Calculate changes to core stability given (measured) profile changes due to RMP

Milestone Text

The application of non-axisymmetric magnetic fields to tokamaks is a useful technique for controlling plasma rotation, transport, and stability. Reliance on this technique in NSTX-U, ITER and future reactors requires sufficient understanding to design an applied field spectrum that will perform the desired actuation without inducing deleterious core MHD modes or displacing the heat flux footprint in high-performance discharges. In particular, non-axisymmetric fields may strongly affect the magnetic geometry in the divertor region, which may have important implications for closed-divertor configurations such as the Small-Angle Slot (SAS) on DIII-D and the Super-X divertor on MAST-U, especially regarding access to detached operation and the deposition of heat flux outside the divertor. Pitch-angle changes caused by non-axsiymmetric fields may also have implications for the design of divertor tiles and acceptable pulse lengths/parameters in NSTX-U and other devices. Modeling of the plasma response to applied non-axisymmetric fields will be carried out to investigate these issues in MAST-U, KSTAR, DIII-D, and NSTX(-U) using ideal, resistive, and two-fluid models. The effect of non-axisymmetric fields on the divertor leg geometry, strike point splitting, and pitch angle at the plasma facing components will be calculated and provided as input for calculations of the heat and particle flux. A range of n=1 and n>1 fields will be considered, consistent with the realizable coil configurations and intrinsic error fields on each device. The effect of profile changes due to non-axisymmetric fields on global MHD stability will also be considered, including non-ideal and kinetic effects, with a focus on high-performance scenarios. Modeling results will be validated against experimental data by comparing with measurements of the plasma response, divertor heat deposition, and observations of instabilities. These results will be used to inform the NSTX-U recovery process and operational constraints.