NSTX

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Some Thoughts on Theory and Modeling Needs for the Advanced Scenarios and Control (ASC) TSG

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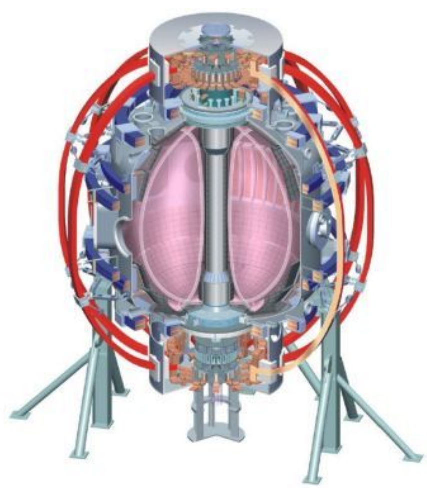

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Two Overarching Questions for the ASC TSG

- 2 questions:
  - 1: How can we control the axisymmetric state of the high-performance plasma?
    - Boundary, kinetic and magnetic profiles, divertor magnetic geometry and power handling.
  - 2: Can we find a high-β, stationary, 100% non-inductive operating point that projects to high fusion gain.
    - Integrate control optimization & physics understanding to achieve goal.

- Context:
  - Programmatic and operational needs of NSTX-Upgrade.
  - The ST vision of a fusion nuclear science facility.

- Next slides: some nearer term needs & desires

Q1: Realtime Axisymmetric Control

- Need a reliable algorithm for the individual and combined control of the current and rotation profiles, along with β_N.
  - The theory of that algorithm should help us to understand to what extent these quantities can be independently controlled given the coupled actuators V_{loop}, P_{inj}, J_{NBCD}, T_{NB} and T_{NTV}.

- More generally, need the ability to test the actual control algorithms in simulations with high degrees of physics fidelity, i.e. flight simulator mode.
  - Could in principle be accomplished by connecting PCS to PTRANSP, CORSICA, or TSC.

- Need the ability to predict the future equilibrium and stability properties of the plasma.
  - "Forecasting" or "faster than realtime look-ahead" of the evolution of the equilibrium
    - (Very) reduced transport models.
  - Future coil currents and boundary shape.
  - Stability assessments of those future states (n=0, n=1, ELM?).
  - Control intervention based on the predictions.
  - Need to be integrated in the structures imposed by GA PCS.

Q2: Stationary, High β, 100% Non-Inductive Operation

- Prediction of the disruptive β_N limit.
  - How close to the ideal wall can we actually operate, as a function of profiles and feedback actuators.
- NBCD with *AE modes
  - At higher values of β_{fast}, *AE modes can lead to redistribution/modification of the fast ion distribution.
  - Theory & reduced models are needed for when these modes will turn on, and what their effect on the pressure & current profile will be.
- Prediction of the thermal & momentum transport
  - The current and rotation profiles are intimately connected to transport and global stability.
    - And vice versa.
  - Ideally, want reduced models like TGLF for the core and pedestal thermal and momentum transport, integrated into transport codes like TRANSP.
  - Would settle for clear predictions for profile moments and characteristics as a function of relevant engineering and/or dimensionless parameters.
    - For instance, pedestal height projections, core density peaking scaling,…
- Need accurate, benchmarked models for HHFW and EBW H&CD within integrated codes such as TRANSP.
  - Need to predict interactions with fast ions, and the effect on current drive
  - and probably SOL losses as well (can this exist in TRANSP?).
- Need a divertor that works…