NSTX-U

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Measured Improvement of Global MHD Mode Stability at High-beta, and in Reduced Collisionality Spherical Torus Plasmas

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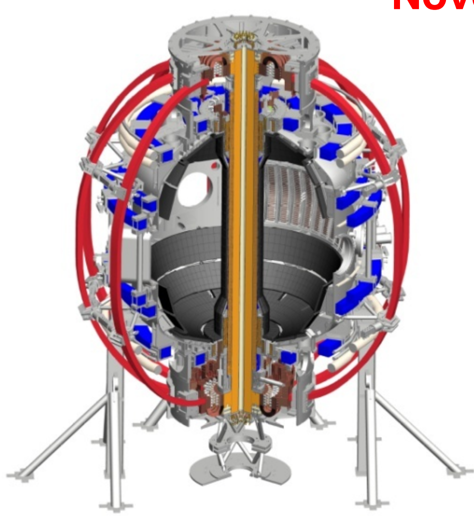

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Overall goals of the talk

- NSTX regularly operates at very high normalized pressure (high beta)– a long-sought goal of tokamak operation
  - Disruptions do occur, but for the first time it has been found that disruption probability does not increase as stability parameters such as β_N/l_i increase.
- The leading physical explanation for this new and highly-favorable result is kinetic stability of global MHD instabilities (RWMs)
  - This physical model represents a significant paradigm shift that has significant implications for extrapolation to future devices such as NSTX-U and ITER, as the dependence of stability on plasma parameters is significantly different than past popular stabilization physics models.
- Disruption avoidance is now the new focus
  - Physics understanding of kinetic stabilization is needed to guide planned disruption avoidance systems (including profile control, active instability control, etc.)

Outline (1)

- NSTX regularly operates at high β, but disruptions do occur.
  - Disruption probability is not highly correlated with β_N exceeding the ideal MHD no-wall limit.
  - Observations from active control experiments and the NSTX disruption database indicated that the highest β_N plasmas were *not* the least stable.
- Physics models examined to explain observation – kinetic RWM stabilization
  - Dedicated experiments in NSTX using low frequency active MHD spectroscopy of applied, rotating n = 1 magnetic fields were conducted specifically to test kinetic RWM stabilization theory.
    - Stability was measured to increase (lower RFA amplitude) at β_N/l_i higher than the point where disruptions were found.
  - Improved stability in this restricted database is found for an experimentally determined range of measured E×B frequency.
  - Kinetic stabilization theory computed using the MISK code for NSTX experimental plasmas.
    - The favorable behavior is shown to correlate with kinetic stability rotational resonances.

Outline (2)

- Stable plasmas can benefit further from reduced collisionality.
  - In agreement with expectation from kinetic RWM stabilization theory.

- Implications for disruption avoidance in future devices (NSTX-U, ITER).
  - Low collisionality plasmas are susceptible to sudden instability when kinetic profiles change.
  - We have an initial simple model of maintaining favorable stability based on maximizing key kinetic resonances.
  - NSTX-U is planning a framework for disruption prediction by multiple means and avoidance via rotation profile control and RWM state-space control.