NSTX

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Advances in High-Harmonic Fast Wave Physics in NSTX

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In collaboration with

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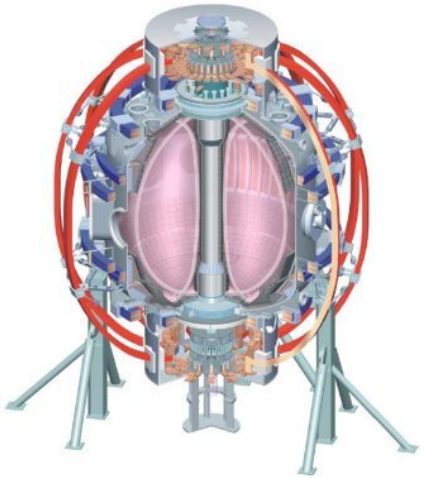

APS – DPP Presentation Outline, Issues & Needs
September 25, 2009

Outline, Issues & Needs - I

- Introduction to HHFW on NSTX
  - Role of HHFW in non-inductive NSTX scenarios
  - Show NSTX HHFW antenna, ideal for studying phase dependence of heating
  - Show 3-D AORSA RF fields to illustrate strong single pass damping, bullet on need to avoid propagation onset density being too close to antenna
- Significant improvements in HHFW core heating achieved when fast wave propagation begins away from the launcher and wall:
  - Li conditioning improved core heating by reducing n_{edge} in front of antenna
  - First observation of HHFW core heating at $k_\phi = 3\ m^{-1}$ in D
  - NSTX record $T_e(0) > 5$ keV with $P_{rf} \sim 3$ MW
  - First significant core electron heating of NBI-driven D H-mode
  - Heating efficiency ~ 40% at $k_\phi = -8\ m^{-1}$ and ~ 66% at $k_\phi = -13\ m^{-1}$
  - GENRAY predicts ~30% to NBI ions for $k_\phi = 8\ m^{-1}$ and ~15% for $k_\phi = 13\ m^{-1}$ during NBI + RF H-mode. **Ben LeBlanc to provide TRANSP analysis.**
  - **TORIC simulations on the effect of Ti on RF deposition (Cynthia Phillips)**
  - Coupling maintained during ELMs if reflection trip level set at high level ($\rho \sim 0.7$)
  - Time derivative of reflection coefficient can discriminate between ELMs and arcs
  - Strong edge pressure gradient appears to lead to large type I ELMs
  - Arcs occur prior to excursion of divertor D_α light

Outline, Issues & Needs - II

- k_ϕ = 8 m^{-1} heating during start-up & ramp-up with Li conditioning shows core electron heating, even at $n_e(0)$ as low as ~ $4x10^{18}$ m^{-3}
- Fast visible camera pictures & IR camera data supportive of fast waves depositing considerable RF energy on the outside divertor plate, especially at smaller k_ϕ
  - Strong RF power interaction with lower divertor, particularly at longer wavelength
  - RF heating on lower divertor plate moves with change in edge field pitch
  - **Analyze fast IR camera data from Joon-Wook Ahn (ORNL) to look at time dependence of divertor power loading relative to ELM timing (Joel Hosea)**
  - **AORSA calculation with the conducting boundary moved to the limiter boundary needed from Dave Green (ORNL)**
- FIDA data clearly show significant broadening of fast-ion profile when HHFW power is applied to NBI-heated plasmas:
  - CQL3D Fokker-Planck code predicts much narrower profile than measured by FIDA, points to need for full orbit treatment
  - **Bob Harvey (CompX) running CQL3D with 1st order treatment**
  - **Myunghee Choi (GA) to run ORBIT-RF with full orbit treatment**

Outline, Issues & Needs - III

- PDI production of energetic ions near plasma edge may contribute to significant edge RF loss and clamp edge rotation:
  - Show ERD edge heating & CHERS rotation profiles during RF + NBI
  - **Guangye Chen (ORNL) has developed a 1-D full wave model for PDI and may provide some of his results for NSTX HHFW (Phil Ryan. ORNL)**
- Double end-fed antenna increased power capability without arcs
  - System voltage achieved in 2009 did not change substantially compared to 2008
  - Currents in antenna frame and/or Faraday shield may determine arcing threshold
  - However, vacuum & plasma conditioning during limited run time did significantly increase P_{rf} and remove Li coatings from antenna structure
- 2009 plasma performance with RF significantly improved compared to 2008:
  - Coupled >4 MW into He L-mode, reached T_e ~ 5.8 keV at 3.7 MW and at 2.7 MW, and achieved H-mode transition
  - Maintained HHFW coupling through L-H mode transition, even in presence of relatively large ELMS in NBI- driven plasmas
- Plans for 2010:
  - Improved ELM/arc discrimination to enable more reliable coupling to core of H-mode plasmas
  - Focus on heating D_2 H-Mode & I_p ramp-up to support of major 2010 milestone