WH&CD
Research Milestones for FY18-19

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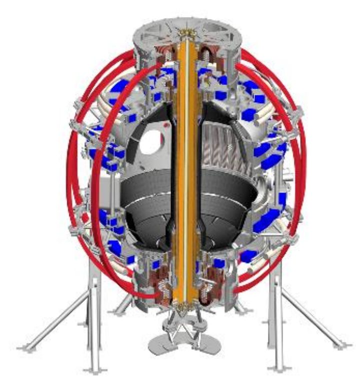
PPPL



R(18-8): Toward self-consistent calculations of fast wave and energetic-ion interactions

- Self-consistent modeling of the interactions between FW and fast ions (beam ions, alpha, minority ions accelerated by the RF) is important for both present-day experiments and also for ITER
  - Fast-ion population can absorb significant amount of RF power
  - RF waves can modify the Alfvénic instabilities driven by beam ions
- IC minority and HHFW heating regimes applications
  - NSTX/NSTX-U
    - Also in collaboration with EP-TSG
  - JET (also D-T campaign), ASDEX, EAST, KSTAR and ITER
- Main tools are:
  - RF solvers: TORIC & AORSA
  - Fokker-Planck code: CQL3D (collaboration with Y. Petrov & B. Harvey (CompX))
  - Monte-Carlo code: NUBEAM (including RF-kick operator)
  - TRANSP

NEW: Assess the impact and the importance of the H species in the HHFW performance in NSTX-U full field plasma

- For NSTX-U B = 1T: 1st and 2nd H harmonics are located at high-field-side and in the core plasma
  - HHFW power can be absorbed by H population reducing electron and/or fast-ion heating
  - few committee members of the Heating Systems DVVR raised the question about this subject (see Chits # R36 & R38)
- H population in the plasma could also have positive implications
  - HHFW could modify the ion temperature (through H species at the 2nd harmonic) in the core plasma
    - Of interest for transport studies
    - Of interest for EP group
- RF simulations for different NSTX-U scenarios w/ & w/o NBI
- Investigate the impact of the tail in the H distribution function (2nd IC harmonic) to electron heating
- Investigate NSTX-U scenarios in which HHFW might modify either T_e and T_i
- We can consider to switch this milestone to FY18 and the previous one to FY19

R(18-8): Toward self-consistent calculations of fast wave and energetic-ion interactions

Self-consistent modeling of the interactions between fast waves and fast ions, introduced either from neutral beam injection (NBI) or from fusion-generated alpha particles, is important for both present-day experiments and also for ITER. The fast-ion population changes the wave propagation and absorption, while the wave damping on fast-ions modifies their distribution. The latter implies that fast-wave heating could impact and perhaps give leverage over Alfvénic activity. Specific to NSTX-U, simultaneous high-harmonic fast-wave (HHFW) heating and NBI is desirable for experiments in turbulence, impurity transport, and Alfvénic activity. However, because of the lower toroidal field of the spherical tokamak, fast-wave heating may accelerate fast ions to loss orbits, and this power-loss mechanism must be studied and then minimized. To this end, self-consistent calculations of the wave fields and the fast-ion distribution function will be pursued by (1) upgrading a full-wave solver to compute the wave fields for arbitrary ion distributions, and (2) iteratively evaluating the full-wave solver with the Monte-Carlo particle code NUBEAM and Fokker-Planck code CQL3D. A recent extension of the full-wave code TORIC v.5 now computes non-Maxwellian ion effects. The TORIC extension will be verified for the standard cases and used to explore effects of independently varying the parallel and perpendicular temperatures for both the ion-cyclotron minority and HHFW regimes. Then, the TORIC extension will be applied to JET (including D-T scenarios), NSTX and ITER scenarios using the fast ion distribution function obtained from NUBEAM and/or CQL3D, giving more self-consistent and accurate calculations of the RF power deposition profile as well as the impact of RF heating on the fast ion distribution function. Attention will be paid to possible fast-wave interactions with the energetic-particle-driven instabilities in previous NSTX experiments and ITER scenarios, at half-field in particular, where the NBI species have an ion cyclotron resonance in the plasma. The coupling between TORIC v.5 and NUBEAM will be implemented in the TRANSP framework and could be used for other fusion experiments (such as ASDEX, EAST, KSTAR, etc.).

NEW: Assess the impact and the importance of the H species in the HHFW performance in NSTX-U full field plasma

The goal of NSTX-U is to operate at full field (B = 1 T) for 5 seconds. For this magnetic field, the first and second harmonics of hydrogen (H) are located at the high-field side and in the core plasma, respectively. In principle, part of the high-harmonic fast-wave (HHFW) injected power can be absorbed by the H population reducing the electron and/or the fast-ion heating. For this reason, full wave simulations of NSTX-U scenarios with different H concentrations will be performed. Plasma scenarios with and without neutral beam injection (NBI) will be considered. Furthermore, the possible impact of the tail in the H distribution function (at the 2nd ion cyclotron harmonic) to the electron heating will be investigated by using the combination of RF full wave and Fokker-Planck codes. Finally, an investigation of NSTX-U scenarios in which HHFW might modify either the electron or the ion temperature (through H species) will be analyzed, as it is of particular interest also for transport studies.