3D Full Wave Fast Wave Modeling with Realistic HHFW Antenna Geometry and SOL Plasma in NSTX-U

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Abstract

- This paper reports the significant advancement of our ability to model and to understand how RF waves interact with the SOL plasma, by realizing for the first time the full torus 3D SOL plasma simulation together with the antenna and core plasma in NSTX-U device in HHFW frequency regime.
- The central tool of the present work is the Petra-M code, which is a newly developed state-of-the-art generic electromagnetic simulation tool for modelling RF wave propagation based on MFEM, open-source scalable C++ finite element method library.

Introduction and Motivation

- Previous NSTX studies of HHFW heating efficiency showed large amounts of HHFW power missing from core
- Strong interactions between HHFW and SOL plasma and bright plasma “spirals”
- Larger SOL losses for high plasma density in front of the antenna
- 2D AORSA & FW2D simulations shown cavity modes in SOL plasma

First full 3D torus sim. including realistic antenna geometry

- Antenna phasing 30 degree
- Ez component of the wave field

Lower phasing has stronger interaction in the SOL plasma

- Antenna phasing 30 degree
- Ez component of the wave field

Strong E field on the wall observed on passive plates

- |E| on the surface

High Harmonic Fast Wave System in NSTX-U

- 12-strap antenna located on the outboard midplane and extends 90º toroidally
- Wave frequency = 30 MHz,
- Up to PFW = 6 MW
- |kz|= 3, 8, and 13 m⁻¹ or nD = 5, 12, and 21 when Δφ = 30º, 90º, and 150º

High Fidelity 3D HHFW antenna and device geometries

Conclusions

- First ever 3D HHFW full wave simulation for NSTX-U plasma including realistic antenna geometry and SOL plasma
- Strong interaction between HHFW and SOL plasma at lower antenna phasing
- Strong E field on the wall surface also far away from the antenna
- Launch power spectra consistent with RF wave theory
- Evaluation of S-matrix for HHFW 12 strap antenna in NSTX-U (vacuum vs plasma)

References

[3] Need to further study and understand FW-SOL interaction
[4] 2D AORSA & FW2D simulations shown cavity modes in SOL plasma

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