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Integration of core/edge plasmas in fullwave RF simulation

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A new efficient full wave simulation approach to solve a driven RF waves problem in hot core and edge SOL plasmas self-consistently is presented. Existing RF simulation codes are integrated to reconstruct self-consistent solutions from solutions obtained from each code. The approach allows for treating hot core plasma, SOL plasmas and launcher structure self-consistently, incorporating complicate 3D antenna structure, and potentially solving driven RF problem in ICRF waves, LH waves, HHFW/Helicon waves with a universal method.

Full wave modeling has been made significant progress in understanding both driven RF waves in core plasma and plasma-antenna coupling. However, in those simulations, the hot core plasma and edge SOL plasmas are solved as separate problems. In the core region, a spectral representation of wave field is used, which allows for accurate formulation of the dielectric plasma response but the region between the launcher and the separatrix was modeled poorly or not at all. In the edge, the simulation models often focuses on a small region in front of the launcher and the core plasma effects are introduced as perfectly radiating boundary or surface impedance. Extending an existing code to treat an entire simulation domain has not been straightforward mainly because, while in core plasma spectral decomposition of the wave field is required to properly treat hot dielectric tensor, retaining complicated 3D geometry such as antenna structure and divertor is needed for accuracy which is incompatible with a spectral representation.

In our approach, we solved the core region and edge regions by TORIC spectral solver and COMSOL finite element package, respectively. The RF electric field on the boundary between core and edge regions is decomposed using spectral modes, and for each region we solve the RF field for all modes. A self-consistent solution is obtained from mode solutions in such a way that continuity of tangential RF fields at the core/edge boundary is satisfied. In this paper, details of formulation and numerical implementation/verification, a comparison of H minority heating and mode-conversion heating on C-Mod and 3D antenna simulation with hot plasma load are presented.
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