Plasma response effects on ITER divertor detachment during RMP ELM suppression

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Detachment of the divertor plasma during application of resonant magnetic perturbation (RMP) fields has been evaluated for the pre-fusion power operation (PFPO) phase in ITER by 3-D plasma boundary modeling with EMC3-EIRENE. An earlier onset of detachment is found in the original strike zone when RMPs are applied, but secondary, non-axisymmetric strike locations appear and remain attached at temperatures above far above 10 eV. The plasma response includes field amplification near the separatrix, and this can result in a magnetic footprint that is extended beyond the dedicated high heat flux region on the divertor targets. The efficiency of Ne seeding to control heat loads to the secondary strike locations is investigated.

The suppression of edge localized modes (ELMs) in high confinement (H-mode) plasmas is essential for a magnetic fusion reactor concept. Application of RMPs has been identified as a promising tool, but compatibility with divertor operation in a dissipative, partially detached state in ITER remains an open issue. Extensive plasma boundary modeling has guided the design of the ITER divertor, but this is based on a 2-D (axisymmetric) equilibrium on which a coupled system of particle, parallel momentum and energy balances for the fluid edge plasma is solved in interaction with neutral gas. The EMC3-EIRENE code suite extends the traditional approach into 3-D by including the perturbed magnetic geometry, which in turn is based on the plasma response computed within a single fluid, linearized resistive magneto-hydrodynamic model by the MARS-F code.

The phasings of the externally applied RMP field can be optimized for ELM control based on the X-point displacement caused by the edge-peeling component of the plasma response. But this is found to be correlated with a relatively large footprint pattern that depends in detail on the balance between field amplification near the separatrix and screening of resonances further inside: the former determines the extension along the divertor targets and the latter determines the radial connection into the bulk plasma from perturbed magnetic field lines. Ultimately, evaluation of divertor performance during RMP application in ITER depends on a robust understanding of competing plasma response processes.

This work was supported by the U.S. Department of Energy under grants DE-SC0012315, DE-SC0013911 and DE-SC0020357, by the College of Engineering at the University of Wisconsin - Madison, and by the ITER Scientist Fellow Network.