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The effect of plasma response on losses of energetic ions in the presence of 3d perturbations in different iter scenarios

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The new physics introduced by ITER operation, of which there is very little prior experience, is related to the very energetic (3.5 MeV) alpha particles produced in large quantities in fusion reactions. These particles not only constitute a massive energy source inside the plasma, but also present a potential hazard to the material structures that provide the containment of the burning plasma. In addition, the negative neutral beam injection (NBI) produces 1 MeV deuterons and the application of ICRH produces minority ions in multi-MeV range, both of which have to be well confined to ensure successful operation of ITER.

Our past analyses of the fast ion confinement have been restricted to vacuum approximation. This approach does not take into account the dynamic response of the plasma to the external perturbations produced by, e.g., ferritic inserts that are imbedded in the ITER wall to reduce the TF ripple, the test blanket modules that also contain ferritic material, and ELM control coils. For long, neglecting plasma response has not been considered an issue because it was assumed that the plasma response simply shields the plasma from external perturbations. However, recent simulation results[1] suggest this is not generally the case. While hindering island formation deep inside the plasma, the plasma response can increase stochasticity at the very edge of the plasma. If the source of energetic ions does not vanish in this region, the stochastic field lines can transport these ions to the walls rapidly and, thus, with very high energy.

In this contribution we employ magnetic backgrounds where the plasma response has been included as calculated by the MARS-F code. The Monte Carlo orbit-following code ASCOT is used to simulate both thermonuclear fusion alphas and fast ions from ITER heating systems in the full 3D magnetic configuration with the plasma response and 3D wall. The analyses covers all major operating scenarios of ITER. Comparing the present simulation results to the ones obtained in vacuum approximation shows that with only ferritic components, the plasma response increases the (small) total load by 10 –15%. However, when the perturbation due to ELM control coils is included, the plasma response brings about significant changes in the power deposition and, in some cases, even increases it.

[1] D. Pfefferle et al., NF 55 (2015) 012001

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