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ITR/P1-33: Fast Ion Power Loads on ITER First Wall Structures in the Presence of ELM-mitigation Coils and MHD Modes

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The new physics introduced by ITER operation, of which there is very little prior experience, is related to the large number of fast ions: fusion alphas, NNBI deuterons and multi-MeV minority ions from ICRH. These particles present a potential hazard to the surrounding material structures. Assuming axisymmetry and neoclassical transport only, the fast ion wall power loads are found tolerable in all scenarios and for all particle species.
However, in ITER the axisymmetry is destroyed by several mechanisms: Finite number of TF coils causes toroidal ripple, the field is further perturbed by the test blanket modules, and the proposed ELM control coils (ECC) cause a field modulation at their own periodicity. All the deviations can cause significant fast ion leakage, leading to localized power loads on the walls. Furthermore, it is highly unlikely that ITER plasmas will be MHD quiescent: the massive fast ion population can drive energetic particle modes that act back to the fast ion population. ITER is also prone to NTM islands. All these MHD phenomena can increase fast ion population at the edge, where transport due to the field aberrations can lead to unacceptably high peak power loads on some first wall components.
In this contribution we address these issues: the effect non-axisymmetry on NBI power loss, and the effect of NTM islands and Alfvénic modes (AEs) on fast ion distribution. Non-axisymmetry: we use the 5D Monte Carlo orbit-following code ASCOT to simulate fast ions in the presence of all relevant mechanisms perturbing the edge magnetic field. The fast ion power loads are found tolerable as long as the edge magnetic field does not become stochastic. The very high NBI power losses, reported earlier, can also be reproduced, but are found to correspond to stochastic edge field that does not support the NBI source profile assumed for the simulations.
MHD effects: we have developed a model applicable for both stationary (NTMs) and rotating (AEs) MHD modes. The island structures are included in the equations of motion, expressed in vector form. Thus the allows arbitrary coordinate system and simulations all the way to the wall, and permits the use of 3D fields. We use the model for ITER to 1) determine the critical NTM island size not be exceeded from the fast ion confinement point-of-view, and 2) estimate the effect of AEs on the fast ion losses.

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