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ITER Energetic Particle Confinement in the Presence of ELM Control Coils and European TBMs

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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.
Since energetic ions are very sensitive to the details of the magnetic field, in this contribution the field was calculated in unprecedented detail, including all the known magnetic perturbations such as ferritic inserts, TBMs and ELM Control Coils (ECC). The FEM solver COMSOL was used to first calculate the magnetization of the ferromagnetic components due to plasma current and currents flowing in the field coils. The perturbation field due to the magnetization was then calculated and added to the unperturbed field integrated from the coils using the Biot-Savart law.
The cases reported here correspond to the 15 MA standard H-mode operation and the 9 MA advanced scenario in ITER. Both thermonuclear fusion alphas and NBI ions from ITER heating beams are addressed. Both species are simulated using the Monte Carlo orbit-following code ASCOT in the full 3D magnetic configuration given by the COMSOL calculations. The first wall also has full 3D features. The ferritic components are found not to jeopardize the integrity of the first wall, but the application of ECC needs further attention, in particular for the potential resonance amplification.

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