EMC3-EIRENE Modelling of ITER Main Chamber Recycling

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The ITER tokamak will be equipped with a rather extensive main chamber visible spectroscopy diagnostic [1] designed to monitor wall recycling emission from hydrogenic species (H, D, T) and gross beryllium (Be) main chamber impurity erosion. Simulations of the latter have recently been performed using the 3-D impurity transport code ERO2 [2] in order to provide estimates of the scrape-off layer (SOL) distributions of BeI and BeII ion density. From these synthetic signals of visible light emission can be reconstructed to guide the choice of diagnostic lines of sight and test the performance of the spectroscopy system for a variety of plasma background conditions from non-active to burning plasma phases of ITER operation. Equivalent signals for the recycling emission in 3-D, taking into account the real first wall structure have been missing until now. This paper describes the results of a series of EMC3-Eirene code simulations which are being performed to provide these neutral fuel atom distributions. The methodology follows a similar exercise using the same code on W7-X for the production of a synthetic visible camera images [3].

First attempts have focused on the burning plasma regime at Q_{DT} = 10, with 100 MW of power into the SOL. The simulation grid extends out to the main chamber walls and takes into account the full 3-D Be first wall panel (FWP) structure, which is shaped to protect the appearance of leading edges due to panel-to-panel misalignment's [4]. This shaping leads to discrete plasma interaction zones on the FWP, for which the total wetted area is only a small fraction of the overall wall surface. For consistency with the ERO2 simulations, exactly the same CAD wall structure is used to build the EMC3-Eirene grid. Benchmark comparisons are made with the SMITER magnetic field line tracing code to cross-check the wetted area patterns. Previously converged EMC3-Eirene plasma background solutions from the ion cyclotron resonance heating antenna coupling study in [5] are used as starting point, adapted to the more detailed wall shape. These simulations vary the SOL cross-field particle diffusivity profile to provide a range of density profiles, steadily increasing the strength of main wall plasma interactions. To improve statistics and minimize CPU demand, periodic boundary conditions are imposed on a single sector model of the ITER vacuum vessel. A high resolution plasma-neutral mesh, consisting of large numbers of radial, poloidal and toroidal surfaces (respectively (132, 642, 17) in SOL) and up to 2x10⁷ Monte-Carlo realizations of neutral particle traces in the presence of a self-consistently computed plasma background, provide adequate statistics on the final neutral atom density distribution for synthetic diagnostic signal reconstruction.

References: