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High fidelity simulations of fast ion power flux driven by 3D field perturbations on ITER

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ITER will be the first tokamak to enter the burning plasma regime and approach ignition; plasma heating will be dominated by 3.5MeV fusion-born alpha-particles and 1MeV Heating Neutral Beam (HNB) injected deuterons (together with a fast particle population resulting from ICRH). In this paper we describe a new Monte Carlo code, designed to simulate fast ion behavior on ITER in the presence of 3D field perturbations. LOCUST-GPU (the Lorentz Orbit Code for Use in Stellarators and Tokamaks) leverages modern Graphics Card technology in order to generate unprecedented high fidelity power and particle flux data using workstation-class hardware. We shall describe how the code delivers HPC (High Performance Computing) class performance to the desktop, the data ingestion part of the workflow (including the production of detailed first wall geometry using CATIA, SpaceClaim and ATTILA, and the generation of plasma response corrections using MARS-F) and ongoing detailed benchmarks and validation tests with the established ASCOT code. We shall also describe experimental validation using data from MAST and finally the results of extensive production runs that are being used to finalize the design of the ITER divertor sub-structure (where, in contrast to core born alpha particles, peripherally born HNB ions impinge upon the divertor structure when ELM coil fields are applied). For the first time, it is possible to routinely use a fast ion code as part of the Virtual Engineering process in order to design components that are compatible with H-mode operation and the required ELM coil currents for mitigating or controlling ELMs under burning plasma conditions. In the case of a 15MA H-mode plasma with 33MW of core HNB injection and a 3D field perturbation made up of toroidal field ripple, ferritic inserts and a 45kAt ELM coil current for toroidal mode number n=3, the total HNB power losses due to 3D fields are estimated using LOCUST to be ˜3.3%; the corresponding figure for ASCOT is ˜3.8%. Small differences are likely due to the fact that for the comparison, ASCOT deployed guiding centre trajectories whereas LOCUST-GPU resolved the full gyro-motion.

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Primary author: Dr AKERS, Robert (UKAEA)

Co-authors: Mr TURNER, Andrew (UKAEA); Ms COLLING, Bethany (UKAEA); Mr VARJE, Jari (Aalto); Mr HESS, Jason (UKAEA); Mr SARKIMAKI, Konsta (Aalto); Mr SINGH, Mahendrajit (ITER Organisation); Dr PINCHES, Simon (ITER Organization); Mr ÄKÄSLOMPOLO, Simppa (Aalto); Dr LIU, Yueqiang (UKAEA)

Presenter: Dr AKERS, Robert (UKAEA)

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