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Integrated Core-SOL-Divertor Modelling for ITER Including Impurity: Effect of Tungsten on Fusion Performance in H-Mode and Hybrid Scenario

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Different plasma performance (energy confinement, discharge duration) has been generally observed in operationally close JET discharges with carbon (C) and ITER-like wall (ILW). Presence of tungsten (W) in ILW discharges is one of the major changes introduced with the wall replacement which may partly explain the differences observed at JET and have an impact on ITER operation. Effect of W on ITER H-mode and hybrid fusion performance is analysed here via integrated core-SOL-divertor modelling performed with ASTRA and JETTO (theory-based core simulations for main species) and COREDIV (impurities and core-SOL-divertor integration) codes used iteratively. Be, He, W and Ne impurities are simulated self-consistently with main plasma species. Core toroidal rotation velocity is also predicted, which is another novelty of this work. The core thermal and particle transport is simulated with the GLF23 transport model which has been extensively validated on a number of H-mode plasmas and hybrid scenarios (HS) in various tokamaks. Here, this model is tested in self-consistent simulations of temperatures, density and toroidal rotation velocity in JET HS. The correlation of the ExB shear amplification factor alpha_E with Mach number has been found in these simulations. The alpha_E and Prandtl number validated on JET are projected to ITER. The COREDIV model has been successfully benchmarked with the JET H-mode discharges and advanced scenarios. Modelling results show that the core-SOL-divertor coupling in ITER plasmas is very strong in presence of W impurity and it affects the operational domains for considered scenarios. The long-pulse H-mode scenario analysed in the density range n=(8.3–11.9)x10^19 m-3 has narrow operational window limited by the tolerable power to divertor (achieved due to optimised neon gas puff and marginally sustained H-mode under given modelling assumptions. The consequences of strong core-SOL-divertor coupling for low density H-mode and hybrid operation where the improvement in fusion performance due to a good core confinement is counteracted by large W production and core radiation are investigated. Sensitivity studies will be presented showing under what conditions the core-SOL-divertor coupling is reduced allowing high H-mode and hybrid performance.

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