7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Integrated modeling of ITER scenarios using the ITER High-Fidelity Plasma Simulator

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Reliable prediction of ITER plasma scenarios' performance, such as the the ramp-up, L-mode, L-H transition, H-mode flat-top and ramp-down, requires accurate integrated modeling simulations. These need to include a wide variety of high-fidelity physics models for core turbulence, impurity and neutral transport, radiation, MHD instabilities, pedestal behavior, the scrape-off layer the divertor, etc. The ITER High-Fidelity Plasma Simulator (HFPS) is the tool being developed to address this need using existing physics models. Due to the extensive range of physics required, compromises on the models' descriptions are often made in order to speed up computations, such as assuming empirical or scaling-based transport coefficients for the core region or simplified boundary conditions at the separatrix. The JINTRAC suite (JETTO + Edge2D/Eirene) [1], that comprises the plasma model of the HFPS, has been recently optimized to use MPI with high-fidelity quasi-linear transport models such as TGLF and QuaLiKiz, removing the need for such simplified assumptions. Heating and current-drive actuators are modeled synergistically using an additional Heating and Current Drive workflow [2], which includes various codes for ICRH, ECRH, NBI and fusion alphas, or alternatively, using stand-alone modules within JINTRAC. The adaptation of these codes to use the Interface Data Structures (IDSs) defined within the Integrated Modelling and Analysis Suite (IMAS) data dictionary facilitates modeling flexibility and results in a standardized output enabling easy comparison and benchmarking with other models. Using these improved capabilities, we have modeled key plasma operation phases in ITER, such as the L-mode, L-H transition and H-mode flat-top. We analyzed the effect of the impurity influx and transport to reveal the implications of a tungsten wall, and studied the feasibility of achieving the required plasma performance in these phases with dominant electron auxiliary heating. These results contribute to the optimization of the heating mix and plasma operational space, and provide guidance on preparing foreseen experiments of the ITER Research Plan.

As part of the HFPS development, a close coupling of JINTRAC to the DINA code [3] is currently being performed. The coupled simulator computes free-boundary MHD equilibria consistent with the evolution of the plasma kinetic profiles, while also applying sophisticated magnetic and kinetic controls. In this presentation, the results obtained during an L-H transition and H-mode flat-top for the fixed-boundary JINTRAC code and the free-boundary JINTRAC-DINA workflow are compared. In particular, during the confinement mode transition involving notable plasma pressure variation and boundary displacement. The impact of the free-boundary equilibrium evolution on the plasma confinement, mode transition, magnetic controls, auxiliary heating, diveror heat-loads and impurity influx is analyzed to improve the predictive capability of the integrated discharge modelling.

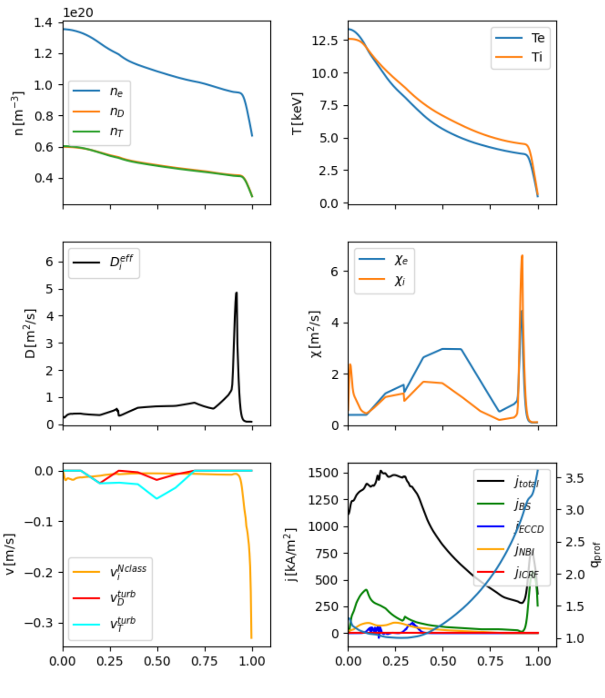

Figure 1: H-mode flat-top JINTRAC-TGLF kinetic profiles. Results for P_{NBI} = 33 MW, P_{ECRH} = 20 MW, considering Ne and W impurities.

References

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