Predictive full radius integrated modelling of plasma current impact on WEST L-mode confinement

E. Vergnaud[1], C. Bourdelle[1], Y. Camenen[2], T. Fonghetti[1], P. Manas[1], P. Maget[1], J.F. Artaud[1], J. Morales[1]

[1]*CEA, Cadarache, France*

[2]*CNRS, Marseille, France*

The energy confinement time scales with plasma current (I_P) as $I_P^{0.95}$ both in L and H-mode [1]. The validated full radius simulation on WEST L mode [2], is extended to 10 L-mode pulses with I_P ranging from 300 to 500 kA, at similar total power and density. The 10 full radius integrated modelling simulations predict an energy content within a RMSE of 11% compared to the experimental one. Since heat, particle and radiation are predicted, the only inputs to the modelling are engineering parameters and separatrix boundary conditions.

The integrated modelling is performed with the High Fidelity Plasma Simulator (HFPS), the IMAS-coupled version of JINTRAC workflow. Turbulent transport (heat and particle incl. impurities) is modelled up to the separatrix using the physics-based quasilinear model TGLFsat2. Stand-alone verification of TGLFsat2 against a higher fidelity gyrokinetic code GKW are carried out for WEST L mode parameters at radii from ρ=0.3 to 0.9. The turbulent fluxes reduction by lowering the safety factor $q \propto 1/I_P$ [3] is captured.

In the HFPS, TGLFsat2 heat and particle fluxes are self-consistently iterated with Low Hybrid Current Drive heating source, impurity transport (N and W) and radiation, the current diffusion and the equilibrium reconstruction. Particle sources adjustments are done by feedback loops on a target line averaged density. Impurities are initially set to match the experimental Z_{eff} (for N) and feedback is adjusted on their separatrix density to align with the radiated power (for W).

For the 10 pulses, the predicted temperature, density and radiation profiles are validated respectively against ECE, interferometry and bolometry. The fit agreement with the measurements ranges from 15-25% relative error, 40-60% with only heat self-consistent modelling and improves to 20-40% when also considering particles self-consistently. The HFPS captures the I_P dependency with a relative error of 32% compared to 48% using the L96 scaling law for the energy confinement time in this set of shots.

References

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