In order to prepare adequate current ramp-up and ramp-down scenarios for ITER, present experiments from several tokamaks have been analysed by means of integrated modelling in view of determining relevant heat transport models for these operation phases. The results of these studies are presented and projections to ITER current ramp-up and ramp-down scenarios are done, focusing on the baseline inductive scenario (main heating plateau current of \( I_p = 15 \text{ MA} \)).

Various heat transport models have been tested by means of integrated modelling against experimental data from ASDEX Upgrade, JET and Tore Supra, including both Ohmic plasmas and discharges with additional heating/current drive. Their ability to reproduce the current profile dynamics during ramp-up and ramp-down phases is evaluated, using as key criterion the plasma internal inductance (\( l_i \)). Two of the tested semi-empirical models [1] are found to provide reasonable agreement relative to this criterion, i.e. are able to model the experimental dataset within +/- 0.15 agreement on \( l_i \). The Coppi-Tang-Redi model [2] is found to be less accurate and provides more deviation on \( l_i \). Conversely, first principle based models such as GLF23 [3] are found to be difficult to use at very low current and close to the plasma edge, resulting in strong deviations in the internal inductance, this one being strongly weighted by the current density close to the edge. By patching the model in the region \( \rho = 0.8 - 1 \), one can however use it for prediction with an accuracy similar to that of the empirical models. Predicted electron temperature (\( T_e \)) profiles vary wildly between models in the early ramp-up phase; however, for most models the predicted \( T_e \) profile converges quite well to the experimental \( T_e \) profile at the end of the ramp-up phase.

Finally, projections to the ITER current ramp-up phase are carried out with the most successful models. The ITER inductive scenario is assumed, both without and with additional heating with up to 20 MW of ECRH at mid-radius from early in the ramp. The differences in both the \( l_i \) predictions and in the \( q \) profiles reached at the end of the ramp-up are rather small for the models tested. Application of 20 MW off-axis ECRH leads to a moderately reversed shear at the end of the ramp-up phase, and to a flux consumption saving of \( \sim 15 \text{ Wb} \).

References


* See the Appendix of F. Romanelli et al., Proceedings of the 22nd IAEA Fusion Energy Conference 2008, Geneva, Switzerland