Quasi-linear model validation against JET measurements and gyro-kinetic simulations

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Integrated modeling has acquired high importance on JET with regard to both experiment interpretation and predictions of high power and D-T future campaigns. Emphasis has been placed on the use of the latest physics based quasi-linear models, i.e. TGLF [1] and QuaLiKiz [2]. Therefore, an intense validation activity is being carried out, both in terms of comparison with gyro-kinetic simulations in stand-alone approach and in terms of validation of multi-channel profile simulations against experimental results. In this study, specific JET transport experiments in L-mode dedicated to the determination of ion and electron threshold and stiffness have been used to validate the models, and in addition two high performance H-mode baseline and hybrid discharges.

The stand-alone comparisons with gyro-kinetic runs have pointed out a number of issues, amongst which a too low ion stiffness level in TGLF, an overestimate of the impact of ExB shear stabilization in the inner half of the plasma in both models, an overestimate of impurity stabilization in TGLF SAT0, the lack of non-linear e.m. stabilization effects in both models. These issues may not prevent in some cases to achieve reasonable agreement in profile simulations due to compensating effects, but will require proper fixes in order to achieve models that are reliable for extrapolations to different parameter ranges.

Multi-channel profile simulations yield mixed results. A number of indications can be derived from the modeling performed so far. The treatment of impurities is an important ingredient and should be dealt with in the closest possible match with experiment. The lack of non-linear e.m. stabilization leads to underestimate of T_i peaking in hybrid-like scenarios in QuaLiKiz, whilst in TGLF this is over-compensated by the low ion stiffness, leading often to T_i overestimates. The ExB stabilization is in general better switched off in the inner half of the plasma, whilst it should be retained in the outer half. With full ExB stabilization, TGLF SAT0 tends to exhibit a run-away behavior in 4-field simulations including rotation predictions. Rotation prediction run-away is much less systematic in QuaLiKiz, with multiple examples of successful momentum transport predictions. The rather high electron stiffness measured calls for taking into account ETGs and multi-scale interaction, which is presently more advanced in TGLF SAT1. Density profile predictions are generally good with both models, with the exception of too flat profiles for high collisionality plasmas with QuaLiKiz. Rotation prediction is so far satisfactory in QuaLiKiz in the cases studied, as long as the external torque sources are dominant, whilst still some implementation issues on the Coriolis pinch need to be fixed in TGLF.

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Topic 4: Multi-channel core transport and integrated modeling