Heat and Particle Physics analysis in advanced tokamak plasmas from JET and JT-60U

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The physics analysis and modelling of heat and particle transport in tokamak confined plasmas is mandatory in order to extrapolate present day experiments to future devices as JT-60SA and ITER or to different plasma conditions in existing devices as the future DT campaign at JET. In particular, advanced tokamak regimes with improved thermal energy confinement and with reduced turbulence activity in the core region, represent a challenge for predictive modelling as the mechanism for turbulence suppression is not fully understood. Therefore, a validation of the main models available for the plasma simulation is mandatory. In order to perform this program, a series of representative discharges of hybrid and Internal Transport Barrier (ITB) scenarios have been selected from JET and JT-60U.

The work has been divided in several stages. First, an analysis of the physics involved in the core region has been carried out with the aim of understanding the possible success or failure of the models applied. Then, predictive simulations for the temperature and electron density profiles have been carried out with three transport models, Bohm–gyroBohm [1], CDBM [2] and GLF23 [3], and by adjusting, as a first step, the pedestal, rotation and density to experimental values whenever available. To carry out this programme, the integrated modelling codes CRONOS [4] and TOPICS [5] are used. Additionally, the transport model TGLF has been also used for simulating hybrid scenarios at JET for both Carbon and ITER Like Wall (ILW) plasmas.

The analysis shows as for hybrid regimes, ITG transport is reduced by the high population of fast ions in the plasma core. This mechanism is better reproduced by the CDBM transport model than by GLF23 which tends to overestimate the impact of the ExB flow shear. Regarding particle transport, GLF23 slightly overestimates the density peaking for this regime. On the other hand, for the JET discharges, the TGLF model better reproduce experimental data, in particular the transition to advanced regimes obtained in dedicated power scans at JET, as it properly accounts for fast ions and electromagnetic effects. The impact of ExB is very limited with this model. Extrapolation of hybrid scenarios to the JET DT campaign will be shown.

Regarding discharges with ITB, CDBM transport model is able to predict the onset of the ITB due to the combination of a negative magnetic shear and strong pressure gradients. The temperatures obtained are close or lower than experimental data. The ITB for the particle transport is reproduced by the GLF23 model but the density peaking is strongly underestimated.

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* See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia