

First principles and integrated modelling achievements towards trustful Fusion power predictions for JET and ITER

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Predictability of burning plasmas is a key issue for designing and building credible future fusion devices. The integration of several physics aspects is mandatory for an accurate extrapolation from present day plasmas, mainly with deuterium (D) as the main ion species, to conditions in which the ion mixture will be dominated by Deuterium-Tritium (DT).

In this framework, an important effort of physics understanding and guidance is being carried out in parallel to the JET experimental campaigns in H, D and T by performing analyses and modelling towards an optimization of the JET-DT neutron yield and fusion born alpha particle physics.

Analyses performed for both baseline and hybrid regimes have shown that reproducibility of heat and particle transport in D plasmas with quasi-linear models as TGLF and Qualikiz is acceptable, showing that in general low density is preferable in the hybrid regime in order to boost the neutron rate generation. This is due to the higher penetration of the NBI beams at low density but as well because in the Ion Cyclotron Resonance Heating (ICRH) schemes usually used, H minority, the 2nd harmonic accelerates the central D beams boosting the fusion reactivity and as well reducing turbulence driven by the so called Ion Temperature Gradient (ITG) modes.

For heat and particle transport, quasi-linear models tend to deviate more in H than in D which makes the prediction for T and DT campaigns less satisfactory. Therefore, the comparison of those models against gyrokinetic simulations has been started which has led to a significant improved understanding of the so called isotope effect which can be reproduced in particular circumstances. Gyrokinetic simulations performed with the GENE code show that the fast ion fraction, the ExB shearing rate or the electromagnetic effects, can lead to deviations from the expected GyroBohm (GB) scaling.

Extrapolations to JET-DT from recent experiments using the maximum power available have been performed including some of the most sophisticated codes and a broad selection of models. There is a general agreement that 11-15MW of fusion power can be expected in DT for the hybrid and baseline scenarios. On the other hand, in high beta, torque and fast ion fraction conditions, isotope effects could be favorable leading to higher fusion yield. This is in line with the fusion power aimed for such campaign.

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