Predictive modelling of D-T fuel mix control with gas puff and pellets for JET 3.5 MA baseline scenario

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Fuel mix control is a relevant problem in present experiments featuring mixed fusion plasmas, and it will be crucial in future fusion reactors operating with a D-T plasma mixture. To maximise the deuterium-tritium (D-T) thermal reactions the plasma mixture has to be close to 50-50. However, the fusion power can be maximised in presence of D neutral beam injection (NBI) in a T rich plasma, so to favour the beam target component of fusion reactions. Integrated modelling can help explore and compare different fuelling schemes and provide guidance on how to design a suitable recipe in order to achieve the desired experimental condition and minimize the T consumption. In this paper, we present the results of fully predictive simulations done in preparation to the D-T operations of the JET baseline scenario. It is shown that a balanced (50-50) D-T plasma mixture can be obtained by balancing the external particle sources. The different fuelling sources such as NBI, gas puff and pellets are dominant particle sources in different regions of the plasma. In the inner core region ($\psi_N < 0.4$) the fuelling injection associated to the NBI is dominant, while gas puffing is the dominant source from the edge to a $\psi_N \geq 0.6$. The effects of pellets depend on the pellet injection parameters and can be used to control the plasma compositions as shown in [1]. Moreover, a different fuelling efficiency can be expected for different hydrogen isotopes. The simulations are performed in the JINTRAC [2] suite of codes using QuaLiKiz [3, 4] as first-principle transport model to predict the plasma current density, the electron density, the ion densities for D and T, the electron and ion temperatures and the toroidal velocity self-consistently with the equilibrium. The boundary conditions are imposed at the separatrix which allows to investigate the effects of the imbalanced gas puff and the effects on the plasma composition of pure D pacing pellets, required in the baseline scenario. A first group of simulations starts form the extrapolations shown in [5], varying the plasma composition with gas puff only in order to explore the dependence of the fusion performance on the T concentration with balanced D-T NBI injection. Introducing D pacing pellets in the modelling, the gas puff sources have to be adjusted in order to keep the plasma mixture close to the 50-50. The ionization sources (not measured at JET) are computed by FRANTIC. Therefore, the results of this modelling can be trusted in terms of fusion performance but can only estimate the experimental particle sources. The modelling results are in line with the experimental measurement obtained during the last D-T campaign at JET, showing a good prediction capability also in D-T plasma mixture.

* *See the author list of "Overview of JET results for optimising ITER operation" Joelle Mailloux et al. 2022 Nucl. Fusion (preprint).*

References

[1] Valovic M. *et al*, "*Control of H/D isotope mix by peripheral pellets in H-mode plasma in JET*" (2021) at *28th IAEA Fusion Energy Conference (FEC 2020)*
[2] Romanelli M. *et al* 2014 *Plasma and Fusion Research* **9** 3403023
[3] Bourdelle C. *et al* 2016 *Plasma Phys. Control. Fusion* **58** 014036
[4] Citrin J. *et al* 2017 *Plasma Phys. Control. Fusion* **59** 064010
[5] Zotta V. K., Garzotti L. *et al* "Moderate beta baseline scenario in preparation to D-T operations at JET" (2021) at *47th EPS Conference on Plasma Physics*