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Plasma core transport of D and T and implications for the fuel cycle

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Deuterium (D)-Tritium (T) plasmas are considered the most promising hydrogen isotope combination for the generation of fusion energy in tokamaks. However, in contrast to electron particle transport, ion transport in mixed plasmas, notably in the presence of T, is less understood.
Differences in the electron density behavior clearly indicated in the first DT campaigns in TFTR and JET that electron particle transport was significantly different in DD vs DT plasmas. However, the understanding of the ion particle transport is more elusive as the direct measurement of ion density profiles is challenging. From the theoretical point of view, several works with gyrokinetic codes pointed out an asymmetry between T and D particle transport in particular plasma conditions, which would lead to lower T particle fluxes than D for the same ion density gradients [1,2]. Integrated modelling in preparation of DT plasmas at JET showed that higher T density peaking than D could be expected in such conditions, resulting in a higher electron density in DT compared to DD [3]. Furthermore, recent analyses have shown that in multi ion plasmas, ion particle transport can behave quite differently to electron transport leading to an insensitivity of core ion densities to particle sources in different isotopes [4,5].
Recent campaigns at JET have given the opportunity to further explore this issue. In the presence of T, higher electron density is obtained, due to mainly an increase on the pedestal density. Possible increase of core density peaking in DT compared to DD is under analysis. The DT ratio has been well controlled by external gas puffing or pellet fueling. No large discrepancies between the DT ratio at the divertor and in the core have been detected. However, some discrepancies between the neutron rate calculated in TRANSP and the experimental one might indicate some differences on the D and T density profiles. Such discrepancies are particularly strong, up to 40%, at low NBI power and low neutron generation. Finally, T plasmas heated with high NBI power in D do not seem to be significantly polluted in the plasma core, confirming the resilience of multi ion plasmas to core particle source.

[1] C Estrada-Mila et al., Phys. Plasmas 12, 022305 (2005) [2] J. Garcia et al., Physics of Plasmas 25, 055902 (2018) [3] F.J. Casson et al 2020 Nucl. Fusion 60 066029 [4] M. Maslov et al 2018 Nucl. Fusion 58 076022 [5] C. Bourdelle et al 2018 Nucl. Fusion 58 076028

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