Core Density Peaking Experiments in Various Operational Scenarios and with Different Isotopes in JET

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Core density profile peaking has been extensively studied by performing several dimensionally matched collisionality (υ*) scans in various plasma operation scenarios on JET. A key focus is determining the relative importance of inward convection versus NBI particle source in creating the observed core density peaking. The transport coefficients are determined from the density perturbation originating from the gas puff modulation.

The following four 3-point υ* scans were performed in JET: (i) high power ELMy H-mode featuring low β, (ii) hybrid like high β H-mode plasma, (iii) ELMy H-mode plasma in Hydrogen and (iv) L-mode with carbon wall. In L-mode, D and V are large in all cases even if the NBI power is much smaller than in the H-mode cases. This already indicates that in L-mode, the role of NBI fueling is small. The neutral particle source over the separatrix is negligible inside ρ<0.8.

The experimental D and V from gas puff modulation data (averaged from ρ=0.5 to ρ=0.8) values are shown in figure 1. In L-mode, D and V are large even if the NBI power is much smaller than in the H-mode cases. This indicates that in L-mode, the role of NBI fueling is small, shown in bottom right corner where transport coefficients almost solely determine the density peaking. The frames on the right column are obtained in transport simulations by applying the experimental D and V profiles and then assuming either the NBI particle source from the PENCIL code (cyan) or assuming it to be zero (black). Unlike in L-mode, the transport coefficients (D and V) are small in H-mode though V is increasing with decreasing υ* and D increases with NBI power. NBI fueling plays clearly an important role in contributing to density peaking.

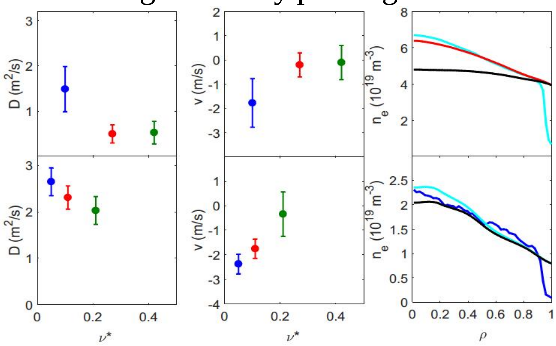

Figure 1. The experimental D and V for the H-mode scan in upper row and in lower row for L-mode scan, colours corresponds to the pulses as in figure 1. The right column shows the experimental determined n_e profiles of the middle υ* pulse (red) in H-mode (top right) and low υ* pulse (blue) in L-mode (bottom right), together with simulated ones using the experimental D and v profiles with the NBI fueling source (cyan) and without it (black).

Gyro-kinetic GENE simulations were performed to infer the peaking factor ($PF = R/L_n = -RV/D$) of background ions at zero flux at various radii. Peaked density profiles are obtained only for L-mode while H-modes discharges show flat or hollow density profiles at ρ=0.6. Consistently with GENE, TGLF and QuaLiKiz transport simulations confirm the dominant role of NBI fueling in producing peaked n_e profiles in JET H-mode plasmas.

The results from both the various scans and modelling all indicate that in H-mode the NBI fueling is a significant, unless even the dominant contributor to the density peaking. In L-mode, turbulent transport with its inward pinch is the dominant contributor. The consequences of this on ITER fueling will be discussed.