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Dominant role of turbulence in determining particle transport and confinement

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In this paper we will show that particle confinement is determined by changes in turbulence characteristic outside mid-radius up to the top of the pedestal in DIII-D H-mode plasmas. We find that the Electron Cyclotron Heating (ECH) density pump-out at low collisionality is the result of an increase in turbulence drive from ρ=0.7-0.9. The frequency of the mode and thus the turbulence type changes from the Ion Gradient Temperature (ITG) to Trapped Electron Mode (TEM) on a much longer time scale. Secondly, we find that particle confinement is strongly reduced in balanced torque injected plasmas, where the ExB shear close to the top of the pedestal drops below the linear growth rate of long wavelength turbulence [1,2]. Both these observations have a strong impact on predictions for ITER, where most of the plasma heating is deposited in the electron channel and the Neutral Beams (NBI) inject relatively low momentum.

One option to counter effects of reduced particle confinement at the plasma edge is to increase peaking of the core density profile. An experimental database has shown that density peaking is influenced by collisionality, and the dominant unstable mode, while theory predicts the q-profile should be inversely proportional with the density gradient [3]. We do find, similar as on AUG, that at mid-radius the frequency of the most unstable mode correlates with the inverse density scale length. Experimentally we observe that 1/q ˜ grad ne, as predicted by theory. The correlation is stronger when Te=Ti and the plasma is in the ITG regime. When we increase the electron temperature with ECH, the correlation becomes weaker.

From these results we can conclude that turbulence plays a dominant role in determining the density profile and particle confinement. However, the predictive capability of particle transport is not well validated and the density profile is assumed to be flat in ITER scenarios [4]. Through comparisons with quasi-linear gyro-kinetic simulations we plan to validate existing codes in order to make better predictions for ITER.

[1] X. Wang et al. PPCF 2015 In review
[2] S. Mordijck et al. PoP 19 (2012) 056503
[3] C. Angioni et al. Nucl. Fus. 52 (2012) 114003
[4] L. Garzotti et al. Nucl. Fus. 52 (2012) 013002

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