

Changes in core electron temperature fluctuations and transport with isotopic mass in L-mode plasmas at ASDEX-Upgrade

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Experiments at the ASDEX Upgrade (AUG) tokamak have been performed to study the differences in core turbulence and transport between L-mode plasmas with varying ion masses, hydrogen (H) and deuterium (D). Discharges with matched core plasma density ($\bar{n}_e=2.5\text{e}19 \text{ m}^{-3}$), input ECRH power (600kW), $B_T=2.4\text{T}$, and $I_P=1\text{MA}$ have been performed in both ions. Electron temperature and toroidal rotation are found larger in D while ion temperature is larger in H. However, differences are within 2-sigma and all gradient scale lengths are found within 1-sigma error bars.

A 24-filter radial comb Correlation Electron Cyclotron Emission (CECE) [1] diagnostic has been recently upgraded with a new antenna that allows a beam radius of $\sim 1.5\text{cm}$ at the resonance, enabling local electron temperature ($\delta T_e/T_e$) fluctuation measurements with $k_{\perp} < 3\text{cm}^{-1}$ ($k_{\perp}\rho_s < 0.36$) resolution between $\rho_{Tor}=0.65-0.85$. Important differences in temperature fluctuations have been found. The total fluctuation level (integrated between 5-100kHz) shows lower fluctuation levels in H compared to D. The ratio of fluctuation levels scales well with the ratio of ion mass. δT_e radial correlation lengths ($L_{r,c}$) are also found smaller in H compared to D. $L_{r,c}$ s in both plasmas obey a $4.5-5.5\rho_i$ scaling, independent of ion mass.

Power balance modeling using TRANSP reveals a significantly larger ($\sim 60\%$) ion heat flux in H versus D. The electron-ion heat exchange term is found to be a strong contributor to the increased heat flux. Local quasilinear gyrofluid and non-linear gyrokinetic simulations have been performed with the TGLF and GENE codes as part of a rigorous validation study featuring synthetic diagnostics to compare against experimental measurements [2]. A sensitivity analysis is underway towards quantifying the reliability of both TGLF and GENE models at various levels of the primacy hierarchy through established validation metrics. Supported by the US DoE under grants DE-SC0014264, DE-SC0006419, and DE-SC0017381.

References

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