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Pedestal particle balance studies in JET-ILW H-mode plasmas

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The relative role of particle transport and edge fuelling in setting the H-mode density pedestal is still a key open question [1]. Although reduced pedestal models have proven successful in predicting the pedestal pressure for a wide range of plasma scenarios [2,3,4], they lack a first principle based, predictive model for the edge density. Prediction of the density pedestal requires understanding of the interplay between edge sources, pedestal stability, ELM, and inter-ELM transport. To progress understanding in this topic, we examined JET-ILW type I ELMy H-modes at constant I_p/B_t, input power and gas fuelling rate, where ELM pacing by vertical kicks [5] and variation in plasma triangularity (δ) were used as tools to disentangle ELM particle losses, inter-ELM particle transport and edge stability to quantify their relative contribution to the pedestal particle balance. Improved pedestal confinement with increasing δ was observed even when the pedestal MHD stability was degraded by vertical kicks, implying that increased triangularity may favourably affect the inter-ELM pedestal recovery.

The workflow developed to quantify the pedestal particle balance uses interpretative EDGE2D/EIRENE [6, 7] simulations to estimate the edge particle source, the NEO drift-kinetic solver [8, 9] to evaluate the neoclassical fluxes and high time-resolution profile reflectometry to measure the ELM particle losses. The interpretative EDGE2D-EIRENE simulations are constrained by experiment: upstream, by kinetic profiles from Thomson Scattering and Li-beam emission spectroscopy and, in the divertor, by target particle flux profiles from Langmuir probes, as well as D Balmer spectroscopy.

Our analysis shows that in the inter-ELM phase, neoclassical main ion transport is negligible, while 80-90% of the edge particle source is exhausted by turbulent transport, with ELM particle losses only moderately contributing to the edge particle transport. This implies that for accurate pedestal density predictions, the identification and characterisation of the dominant micro-instabilities in the pedestal is a matter of paramount importance. Recently, exceptional progress has been made in studying pedestal heat transport with gyrokinetic modelling, but less emphasis was devoted to particle transport, primarily due to lack of edge particle source measurements. Our workflow provides quantitative information of the pedestal particle source term to gyrokinetic simulations aimed at advancing the understanding of density pedestal formation.

The analysis of recent tritium ELMy H-modes will also be presented, in which variation of the main ion isotope mass is exploited to disentangle the contributions of neutral source (via changes in the neutrals mean free path) and particle transport to the formation of the density pedestal.

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