Impact of the main ion species on the ASDEX Upgrade Pedestal

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Future fusion devices, such as ITER, will operate with a deuterium tritium mixture, whereas current experiments mainly use deuterium or hydrogen. Studying the isotope dependence is, therefore, crucial to accurately predict the performance of these future fusion devices. Previous studies have demonstrated positive isotope mass scaling of the thermal energy confinement time in H-mode plasmas. This phenomenon has been observed in several major tokamaks, including JET [1], JT-60U [2], ASDEX [3] and ASDEX Upgrade [4]. To further investigate the isotope dependence, this analysis compares plasmas with different main ion species from the ASDEX Upgrade tokamak, focusing on the pedestal region to understand the phenomena where the main ion type plays an important role. Discharges with different main ion species, but otherwise matched engineering parameters were selected for comparison. The analysis includes a comparison of kinetic profiles (temperature, density, and pressure profiles), stability analysis against peeling-ballooning modes, and investigation of inter-ELM transport. In addition to the main ion comparison, the study varies plasma shaping, the main ion fuelling, and the heating power (NBI and ECRH up to 10 MW total heating power). Varying these parameters alongside the main ion species provides a better understanding of their influence on pedestal behaviour and overall plasma confinement. The comparison between deuterium and helium discharges reveals differences in the pedestal behaviour. In deuterium, higher triangularity increases the pedestal top pressure, while helium shows no variation. Although ELMs are present in all studied cases, stability analysis suggests that deuterium operates close to the ideal MHD stability limit, whereas helium remains far from it. The inter-ELM transport analysis shows higher electron heat diffusivity in helium. The observed differences emphasize the importance of understanding the pedestal behaviour for different main ion species.

References

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