How Nitrogen seeding securizes plasma ramp-up in the metallic environment of WEST

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The initial phase of a plasma scenario is critical in tokamaks with metallic walls, since heavy impurities radiate in the plasma core and can generate MHD unstable plasmas or trigger a radiative collapse before heating systems can enter into play [1, 2, 3]. On the WEST tokamak, solving this issue has been instrumental for the development of reliable plasma operation. Several recipes are known to help solving this problem, mainly early electron heating, density increase or light impurity seeding. On WEST, Nitrogen injection during the initial plasma ramp-up is associated with an increase of the core energy confinement as well as with a peaking of the current density, indicating a displacement of the ohmic heating towards the core, driven by edge cooling. This effect is consistent with the underlying modification of the Tungsten emission that decreases at the inner divertor, due to the temperature drop possibly combined with a reduced sputtering, a process in which light impurities are known to play a significant role [4, 5]. The balance between wall erosion by light impurity impact, plasma cooling by the increased radiation at the edge and in the core, is evaluated by combining experimental measurements with integrated modeling approaches using COREDIV, RAPTOR and METIS for the plasma evolution, as well as SOLEDGE-ERO for addressing the contamination issue. The modification of the plasma equilibrium obtained via Nitrogen seeding is also shown to improve the stability of resistive MHD modes in the edge region. In the absence of actuators for controlling impurity contamination, actions taken during this early phase are also strongly correlated with the performances reached in the high power phase.

References

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