Understanding tungsten accumulation during ICRH operation on WEST

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The transport of impurities in a tokamak with metallic plasma facing components can lead to accumulation events and radiative collapses, and this is particularly true when neoclassical transport is enhanced by sources of impurity poloidal asymmetry [1]. On WEST, where the heating scheme only uses RF waves, these events are rare, but still radiative collapses are sometimes observed [2]. We analyze here the case of a pure ICRH pulse with the collisional transport codes FACIT [3, 4] and NEO [5], the suite of codes EVE [6] and AQL [7] for the ICRH heat deposition and temperature anisotropy, and the METIS integrated simulation tool for the current profile evolution [8]. The physics of collisional tungsten transport in this case combines several effects: i) the fast ion temperature anisotropy driven by the minority ICRH scheme drives tungsten accumulation, but ii) the ICRH induced toroidal rotation moderates it; iii) Finite Orbit Width effects reduce the ICRH drive, but iv) they also reduce the favorable fast ion Temperature Screening effect as well as v) the electron heat source; finally, vi) tungsten accumulation mitigates the ICRH drive by increasing the parallel temperature of the fast ions in a self-limited process. The analysis of this complex interplay shows that indeed the Temperature Screening effect is largely reduced, and that the ICRH-driven accumulation at low rotation is strongly moderated by the increase of the parallel temperature. The tungsten peaking as a function of toroidal rotation (that is not measured) exhibits a V-shape, and bolometry measurements (from which the tungsten content can be inferred) are consistent with two solutions for the toroidal rotation. Theory predicts, however, that the accumulation process is mitigated by the temperature drop on the high rotation branch while it is accelerated on the low rotation one, thus favoring the latter hypothesis for explaining the observed collapse.

References

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