Multiplet effects in radiation losses during discharge quenching by intense argon injection in ITER

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One of conditions of the experimental tokamak reactor ITER's safe operation is the possibility of disruption instability mitigation by massive injection of inert gases, in particular, of argon and neon. While modeling in [1] of Ar and Ne massive gas injection (MGI) in the ITER 15 MA Q=10 baseline scenario, the MGI is carried out at the quasi-stationary stage of discharge (flat-top of the current). For modeling of main plasma parameters, the ASTRA transport code was used, integrated with the ZIMPUR [2] code which describes the dynamics of charge states, radiation losses and transport of impurities (radiation losses were simulated in [1] for optically thin coronal plasma).

Here we present the results of estimating the following effects in scenario [1]: (i) radiation imprisonment, using the Escape Probability model, (ii) deviations from coronal model, caused by collisional quenching, (iii) fine structure of atomic levels (multiplet splitting). This consideration is stimulated by the results [3] where the impact of plasma opacity on the disruption mitigation by the MGI in tokamaks was found (only the first two effects were considered there). For the most strongly radiating ions at various stages of discharge quenching (e.g., highly ionized atoms at the initial stage of penetration of impurity into plasma and weakly ionized atoms at the stage of impurity stirring practically throughout the entire plasma volume), the optical thickness for the ionic strongest lines appears to be about 10. However, it has no significant effect on the total radiation power losses of plasma in the quenching scenario [1]. The most significant effect appears to be the multiplet splitting, which provides the increase of radiative losses, e.g., for weakly ionized atoms at low temperatures, because of the contribution from $\Delta n=0$ transitions with lower excitation energy than that in the model of multiplet-averaged energy levels.

References

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