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Theoretical study of electron-impact ionization for W^{+} ion

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Tungsten is commonly used as a plasma-facing material in tokamak fusion devices because it has a very high melting point and resists erosion. However, collisions with high-energy plasma particles can release tungsten atoms and ions into the plasma. These heavy impurities increase radiation losses and reduce plasma performance. Therefore, accurate ionization cross sections are important for plasma modeling, diagnostics, and predicting impurity behavior under different operating conditions.

Aim of the current work is to analyze single ionization cross sections for the W^{+} ion using the scaled distorted wave (sDW) approximation [1]. The analysis includes energy levels of the ground $5d^{4}6s$ configuration of the W^{+} ion. The sDW results are compared with experimental data [2, 3] and distorted wave (DW) calculations.

Radial orbitals for considered configurations of tungsten ions are calculated using the Flexible atomic code (FAC) [4] where coupled Dirac equations are solved for a local central potential. Transitions are analyzed among configurations of the W^{+} and W^{2+} ions. Excitation cross sections to the autoionizing configurations are estimated in order to determine excitation-autoionization (EA) contribution. In addition, the radiative and Auger rates from these subconfigurations are calculated to evaluate autoionization branching ratios for the produced subconfigurations. The DW approximation is used to calculate the direct ionization (DI) and excitation cross sections [4].

DI process includes the 5d and 6s subshells for the $5d^{4}6s$ configuration. DI from the deeper subshells of the studied configuration produces autoionizing configurations that are above the double ionization threshold. These excited autoionizing configurations primarily decay through autoionization and, therefore, result in higher ionization stages than W^{2+}.

The first step of the EA process is analyzed for excitations from the 4f, 5d, and 6s subshells of the $5d^{4}6s$ configuration. The excitations up to shells with the principal quantum numbers $n \leq 30$ and orbital quantum number $l \leq 5$ are included in the study.

The DI process dominates for all studied energy levels and contributes $\sim 80\%$ to the total ionization cross sections. EA channels corresponding to excitations from the 5d subshell dominate over the EA 4f and EA 6s channels for all energy levels of the ground configuration.

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