ELECTRON IMPACT IONIZATION OF W^{5+}

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Energy losses determined by radiation of impurities in various ionization stages have to be controlled for the successful ignition of a deuterium-tritium plasma in thermonuclear reactors. Ionization balance in the plasma is mainly established by electron-impact ionization and recombination processes. Such processes have to be well understood for predicting possible plasma scenarios.

The main goal of the current work is to present theoretical study of electron-impact single ionization cross sections for the W^{5+} ion. The theoretical study includes direct and indirect processes. Level-to-level calculations were performed for the $5d$ ground configuration and for several excited configurations of W^{5+}. For all contributions considered in the determination of the total single-ionization cross section, autoionization branching ratios for every level of the W^{5+} ion populated by excitation of one of the initial states were calculated accounting for Auger and radiative decays from the level.

The Flexible Atomic Code (FAC) [1], which employs the Dirac-Fock-Slater method, is used to calculate energy levels, radiative and Auger transition probabilities, and electron-impact excitation and ionization cross sections. The cross sections are obtained in the distorted wave (DW) approximation. Excitations of the $4f$, $5s$, $5p$, and $5d$ electrons from the $5d$, $6s$, $4f^{13}5d^2$, $5p^55d^2$, and $4f^{13}5d6s$ configurations up to the shells with $n = 12$ are taken into account in the study to ensure convergence of the EA data. Furthermore, the excitations to all subshells with orbital quantum numbers $l \leq 6$ are studied. It can be seen that there is a difference of $\sim$20% between the $n = 7$ and the $n = 12$ result at the peak of the cross section (Fig. 1). Radiative damping of the autoionizing states leads to diminishing of the total ionization cross sections by $\sim$14% at the peak.

The influence of initial- and final-state correlation on electron-impact ionization cross sections from the ground configuration is investigated. Correlation is taken care of by the implementation of configuration interaction applying suitable basis sets. The correlation effects are studied for the strongest DI channels and excitations that lead to single ionization. The configuration interaction strength (CIS) [2] is employed to determine a list of admixed configurations having the largest influence on the configuration under consideration.

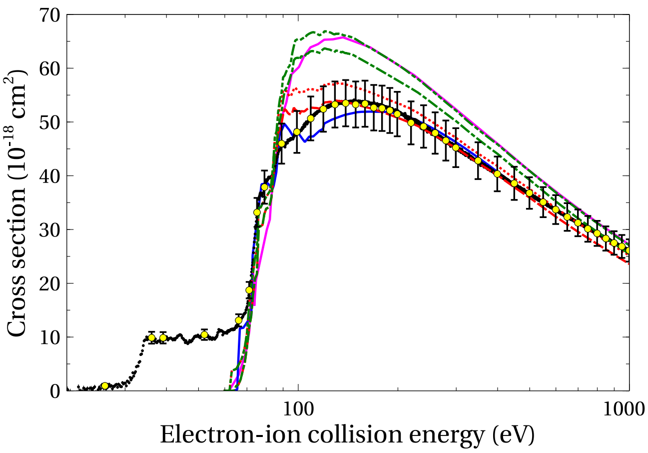

Fig. 1. (Color online) Comparison of the present experimental data to the theoretical calculations for single ionization from the ground levels of W^{5+}. Circles with light shading (yellow) and associated total error bars represent experimental absolute cross sections. The small black dots with statistical error bars of the size of the symbols are the result of the fine-step energy scan. Present theoretical results including DI and EA for excitations with $n \leq 7$ are shown by the dashed (red) line for the $5d\,^2D_{3/2}$ ground level and by the dotted (red) line for the $5d\,^2D_{5/2}$ level. The dash-dotted (green) line represents the $5d\,^2D_{3/2}$ cross section and the dash-dot-dotted (green) line the $5d\,^2D_{5/2}$ cross section which both contain EA contributions associated with excitations up to $n = 12$. The CADW results obtained by Pindzola and Griffin [3] including excitations with $n \leq 6$ are represented by the solid (blue) line that is close to the experimental data points.

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