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Electron-impact ionization of multiply charged tungsten ions

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Synopsis Absolute cross sections for electron-impact ionization of W^{q+} ions ($q \leq 17$) are measured using a well established electron-ion crossed beams technique. A special problem with many-electron tungsten ions is the existence of large numbers of long-lived excited states and their presence in the primary ion beams employed in the experiments.

In a fusion plasma, heavy impurity atoms such as tungsten give rise to excessive radiative energy losses. In spite of its adverse effects in a fusion plasma, tungsten with its unique physical and chemical properties is considered an indispensable material for plasma-facing walls of a fusion device. The presence of W^{q+} ions in the fusion plasma is thus unavoidable. Understanding the influence of tungsten as a plasma impurity and its impact on the plasma requires detailed knowledge about atomic processes and about the atomic structure of tungsten in all stages of ionization [1]. Motivated by the renewed interest in tungsten, a comprehensive effort is being made to perform both experimental and theoretical studies on electron-impact ionization of tungsten ions in low to intermediate charge states.

Ionization cross sections are measured employing the well-established crossed-beams method in the collision energy range from the corresponding thresholds up to 1000 eV. Additional to absolute cross section measurements, fine-step energy scans are recorded to reveal information on indirect ionization mechanisms (see, e.g., [2]). The configuration-averaged distorted wave (CADW) approximation is employed to elucidate possible direct-ionization (DI) and excitation-autoionization (EA) contributions to the measured cross sections. Figure 1 shows a comparison of the present experimental single-ionization cross sections of W^{5+} ions with results of Stenke *et al* [3]. The cross section has an abrupt onset already at about 30 eV below the $W^{5+}(4f^{14}5d)$ ground-state ionization threshold expected at 64.8 eV indicating the strong influence of metastable states in the parent ion beam. These long-lived excited states are most likely associated with $[Xe]4f^{13}3d^2$ and $[Xe]5p^54f^{14}3d^2$ configurations. They contribute to the measured signal predominantly via $5d \rightarrow 5f$ excitations. The assumption of a 10% metastable fraction can explain the EA step at around 33 eV.

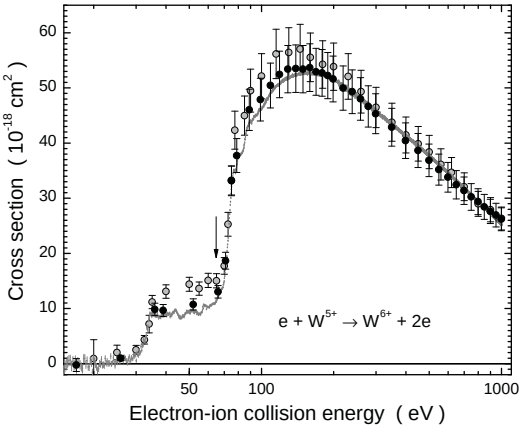

Figure 1. Experimental cross sections for single ionization of W^{5+} ions. The present absolute data are represented by solid circles, the scan data by small dots. The data of Stenke *et al* [3] are represented by the light shaded circles. The vertical arrow indicates the expected threshold for ionization of $4f^{14}5d$ ground state W^{5+} ions. In the experiments by Stenke *et al* the fraction of metastable ions in the parent beam was apparently about 30% higher than in the present measurements.

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