Electron-impact ionization of tungsten ions

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Synopsis Electron-impact ionization of tungsten ions has been measured in the energy range from threshold up to 1000 eV. Configuration-averaged distorted wave calculations were used to explain the experimental data.

In future Tokamaks, extreme conditions at the plasma edge require plasma-facing wall elements to possess high sustainability against sputtering. Due to its stability and robustness tungsten has been identified to be the most promising candidate material for the divertor plates in the upcoming largest thermonuclear device ITER. At the same time, huge loads of incident particles on the plate surfaces will make the presence of sputtered tungsten atoms (and, of course, ions) in the edge plasma unavoidable. Tungsten atoms and ions in a wide spectrum of charge states lead to significant energy losses which must be reliably estimated. In order to perform such estimations, reliable data on atomic processes of tungsten ions are of crucial importance [1].

We present electron-impact ionization cross sections (CS) of tungsten ions studied in the energy range from the corresponding signal onsets up to 1000 eV. Absolute CS values have been measured using the animated-beam technique implemented in a crossed-beams experiment. Additionally, a fine-step energy-scan technique has been employed to uncover fine structures in the studied CSs [2]. the ion charge states q=1, ..., 6, 8, 11, ..., 19 have been investigated. In order to explain the measured CSs, configuration-averaged distorted wave (CADW) calculations have been performed considering both direct- and indirect ionization mechanisms. Ions in long-lived excited states have been found to be present in the experiments and were also included in the calculations. Comparisons of the experimental and theoretical data shows good to very good agreement. In the energy ranges below CS maxima the dominant role of indirect ionization processes via excitation to autoionizing states is revealed. For high ionic charge states, the majority of such excited autoionizing states are supposed to decay via Auger processes, while, for lower charge states, radiative damping plays a significant role. The figure shows the CS for W^{19+} with comparison of the present experimental and theoretical data sets.

Together with the investigations on photoionization and dielectronic recombination [3, 4], present results were obtained within a comprehensive effort to provide accurate atomic data on photonic and electronic interactions of tungsten ions for further use in plasma modeling.

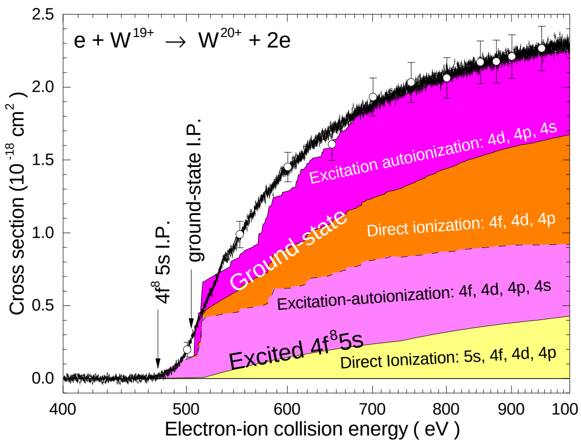

Figure 1. Ionization cross section of W^{19+}: experimental data (open dots, black line) compared to CADW calculations (individually shaded areas represent contributions of different ionization mechanisms).

References

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