# Dielectronic recombination of xenonlike tungsten ions



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# Dielectronic recombination of xenonlike tungsten ions

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**Synopsis** Dielectronic recombination (DR) of xenonlike $W^{20+}$ forming $W^{19+}$ has been studied in the collision energy range 0–140 eV. The measured rate coefficient is dominated by strong DR resonances even at the lowest experimental energies. At temperatures relevant for fusion plasmas, the experimentally derived plasma recombination rate coefficient is over a factor of 4 larger than the theoretically-calculated rate coefficient which is currently used in fusion plasma modeling. The largest part of this discrepancy stems most probably from the neglect in the theoretical calculations of DR associated with fine-structure excitations of the $W^{20+}([\mathrm{Kr}]4d^{10}\,4f^8)$ ion core.

Atomic spectroscopy and collision processes involving tungsten ions currently receive much attention, since tungsten is used as a wall material in nuclear fusion reactors. Consequently, tungsten ions are expected to be prominent impurities in fusion plasmas. Radiation from excited tungsten ions leads to substantial plasma cooling which has to be well controlled in order to maintain the conditions for nuclear fusion. Thus, a comprehensive knowledge of atomic energy levels and collision cross sections is required for a thorough understanding of the spatial and temporal evolution of the tungsten charge states and emission spectra in fusion plasmas. To date, only a small fraction of the needed atomic data has been derived from experimental measurements and most comes from theory.

Here, we present the result of the first storage-ring electron-ion recombination experiment using tungsten ions, i.e., the *absolute* experimental rate coefficient of Xe-like $W^{20+}$ recombining to form Cs-like $W^{19+}$ [1]. Figure 1 shows the measured $W^{20+}$ merged-beams recombination rate coefficient as a function of electron-ion collision energy. Most dramatically, the rate coefficient at energies of at least up to 30 eV is about three orders of magnitude above the RR rate coefficient estimated from a hydrogenic calculation.

This large rate coefficient is caused by individually unresolved, huge DR resonances at very low electron-ion collision energies. These strongly influence the plasma rate coefficient even at temperatures above 100 eV, where the fractional abundance of $W^{20+}$ is expected to peak in a fusion plasma. Because of the extraordinary complexity of the $W^{20+}$ atomic structure, no definitive assignment of the measured DR resonance features could be made. Atomic structure calculations suggest that DR associated with fine structure excitations of the $W^{20+}([\mathrm{Kr}]4d^{10}\,4f^8)$ ion core makes major contributions to the observed low-energy DR resonance strength [1]. This fact seems to have been disregarded in the theoretical calculation of the $W^{20+}$ plasma DR rate coefficient which is used for plasma modeling by the nuclear fusion community. Their resulting rate coefficient is at least a factor of 4 lower than the present experimentally-derived result.

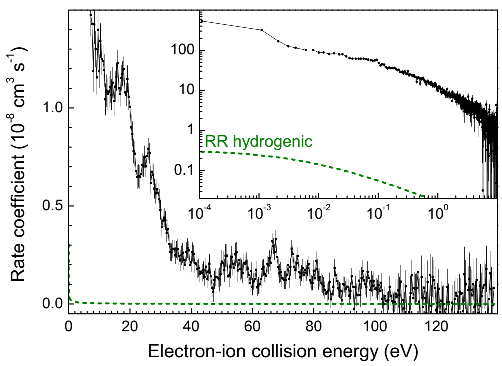


**Figure 1**. Measured merged-beams rate coefficient for electron-ion recombination of $W^{20+}$ ions as function of relative collision energy. The short-dashed curve is the calculated RR rate coefficient using a hydrogenic approximation. The inset shows the same data in a log-log representation and a finer energy binning emphasizing the rate coefficient at very low energies.

## References

[1] S. Schippers *et al* 2011 *Phys. Rev. A* **83** 012711

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