Theoretical dielectronic recombination rate coefficients for lowly charged tungsten ions

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Synopsis Dielectronic recombination (DR) of lowly charged tungsten ions W^{q+} (q = 5-11) has been investigated by theoretical calculations using the flexible atomic code (FAC) based on the relativistic *jj* coupling scheme. All possible, sizable, level-resolved resonances are included to the total DR rate coefficients with the detailed branching ratios. The calculated DR rate coefficients for W^{5+} and W^{6+} have been compared with other available previous results by Hartree-Fock Relativistic (HFR) calculation using Cowan code and the differences have been discussed.

Tungsten ions W^{q+} (q = 5-11) are main ions forming mean charge below the electron temperature ~100 eV in fusion tokamak plasma. Spectral lines of the ions exist around 14 - 25 nm wavelength which is useful to VUV diagnostics for edge region of fusion tokamak. The spectral line intensities emitted from plasma depend on the fractional abundance of the ions which can be determined by ionization and recombination rate coefficients of the ions. Dielectronic recombination (DR) is the dominant recombination process for those W ions and the DR data is essential for the spectroscopic modeling combined with impurity transport modeling.

DR calculation for the lowly charged tungsten ions including all possible, non-negligiable, and level-resolved resonances has been carried out using the flexible atomic code (FAC) [1] based on the relativistic *jj* coupling scheme. Detailed branching ratios of the resonances have been calculated with the methods similar to the previous work for Ni-, Cu-, and Zn-like W^{q+} (q = 46-44) ions [2].

The ground state configurations are ([Kr]$4d^{10}$) $4f^{14}5s^25p^65d$, $4f^{14}5s^25p^6$, $4f^{13}5s^25p^6$ (or $4f^{14}5s^25p^5$), $4f^{14}5s^25p^4$, $4f^{14}5s^25p^3$, $4f^{14}5s^25p^2$, $4f^{13}5s^25p^2$ (or $4f^{14}5s^25p$) for W^{q+} (q = 5-11), respectively. For W^{5+} and W^{6+} there are previous DR data by semi-relativistic Hartree-Fock Relativistic (HFR) calculation using Cowan code [3,4]. But there is no available DR data by ab-inito calculation or experiment for other W^{q+} (q = 7-11) ions. Presently calculated DR rate coefficients for W^{5+} and W^{6+} have been compared with the previous results [3,4] and which are shown in figures 1 and 2. The differences between present results and the previous results are small at high energies over ~ 100 eV but become larger at lower energies below ~ 100 eV. The discrepancy has been discussed by looking into the included resonances and the detailed BR channels in both the present and the previous calculations.

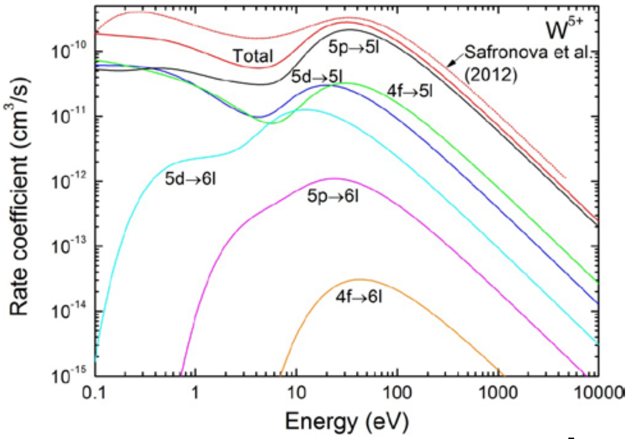

Figure 1. Calculated DR rate coefficients for W^{5+}. The previous total rate coefficient by Safronova et al. [3] is also displayed for comparison.

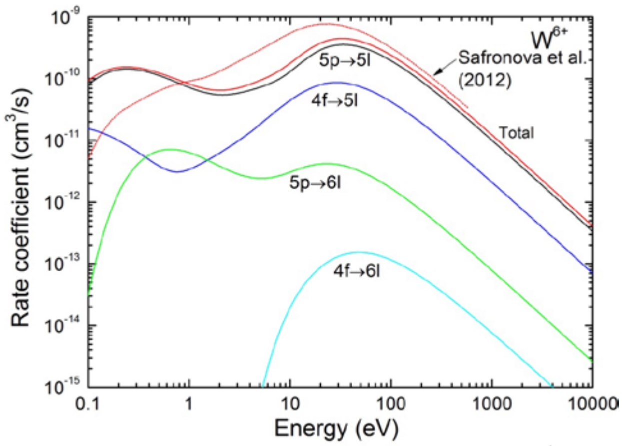

Figure 2. Calculated DR rate coefficients for W^{6+}. The previous total rate cefficient by Safronova et al. [4] is also displayed for comparison.

References

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