The Tungsten Project: A complete set of isonuclear dielectronic recombination rate coefficients for use in magnetically confined fusion plasmas

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Synopsis A requirement of collisional-radiative models of magnetic fusion plasmas is that a detailed set of atomic data for the constituent ions is included. For the upcoming fusion reactor ITER, this is a difficult requirement to fulfill as the divertor will be made of tungsten. For this metal, partial final-state resolved dielectronic recombination (DR) rate coefficients are required. For this purpose we created *The Tungsten Project*. We give a brief overview of the methods used, and present results for a revised steady-state ionization balance.

The upcoming experimental reactor, ITER, is due to produce its first plasma in 2020. The divertor is a plasma-facing component, and will be composed of Tungsten. Tungsten has been chosen for its ability to withstand large power loads. As a plasma facing component, tungsten impurities will be introduced into the main body plasma through sputtering. The high atomic number of tungsten means it is an excellent radiator, which can result in the plasma being cooled, and potentially quenched. Due to the plasma densities involved, understanding the impact of tungsten impurities in the plasma requires detailed collisional-radiative modelling. This in turn requires partial final-state resolved DR rate coefficients for the complete isonuclear sequence. Multiple efforts resulted, including that of Pütterich et al. [1], who used an average-ion method to calculate recombination rate coefficients for the sequence.

To address the need for partial final-state resolved DR rate coefficients for tungsten, we created *The Tungsten Project* [2, 3]. The project used the distorted-wave code AUTOSTRUCTURE [4] to calculate the data using κ-averaged relativistic wavefunctions in level (IC), term (LS), and configuration (CA) resolution. The data are freely available on the Atomic Data Analysis Structure (Open-ADAS) website (http://open.adas.ac.uk) in the standard adf09/48 formats, the definitions of which can also be found on Open-ADAS.

In Figure 1, we have plotted the ionization fractions calculated using Putterich et al's [1] recombination rate coefficients, and the present data. For our fraction, we have replaced Pütterich's data with ours for ionization stages W^{74+}–W^{38+}. In both cases, we used the ionisation rate coefficients of Loch et al. [5]. It can be seen that by using the present data, there are significant shifts in both the peak fractional abundance, and peak abundance temperature.

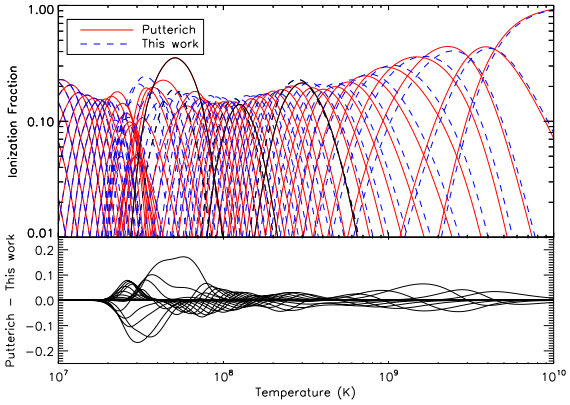

Figure 1. Comparison of ionization fractions calculated using Pütterich et al's [1] data (solid red), and the present data (blue dash) for W^{74+}–W^{38+}. The bottom plot shows the arithmetic difference between the two fractions.

With the completion of the tungsten project attention now turns to modelling efforts. The data described will be used not only in models of the ITER plasma, but will also help inform the construction of the first commercial demonstration fusion plant, DEMO.

References

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