The Tungsten Project: Dielectronic Recombination data for the International Thermonuclear Experimental Reactor (ITER)

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Synopsis The plasma facing components in ITER will be constructed using Tungsten. Sputtering of plasma against these walls introduces Tungsten impurities into the plasma, possibly causing quenching. As data for Tungsten in the relevant charge states is historically poor, this project aims to calculate this data, providing partial and total Dielectronic/Radiative Recombination rates for use in collisional-radiative modelling of the ITER plasma.

The International Thermonuclear Experimental Reactor (ITER) is thought to be the penultimate step in realizing commercial nuclear fusion power. ITER will dwarf the Joint European Torus in terms of physical size, core temperature, and plasma volume.

Tungsten has been chosen as a plasma facing metal for the ITER reactor. Prior to this, reactors such as the Joint European Torus (JET) used walls composed of Beryllium and/or Carbon, however, the former is extremely toxic to humans, making reactor decommissioning more difficult, while the latter is susceptible to high tritiation rates. Tungsten is a non toxic metal, and also has very low tritiation rates.

One disadvantage of using Tungsten for the reactor wall is its potential to quench the plasma. Tungsten has 74 electrons, and will hence not be completely ionized if introduced into the plasma. Therefore, it is necessary to model the effect of introducing Tungsten impurities into the plasma. This can be seen in Figure 1, where two sets of ionisation balance calculations are presented as a function of temperature in the low electron density limit. While both sets use ionisation rate data from [1], the red-solid curve uses recombination data from [2], and the blue-dashed curve uses data from [3]. This figure demonstrates the large uncertainty in the current recombination data used over the whole range of charge states that will arise in ITER.

The Tungsten Project is an effort to calculate ab initio the Dielectronic/Radiative Recombination (DR and RR respectively) rates for each ion. The DR and RR data is being calculated as described in [4] and [5] respectively, using the atomic collision package AUTOSTRUCTURE [6]. Results of the first phase of this program (H-Ar like) will be presented, covering the core component of the ITER plasma. We also provide partial recombination rates, enabling quantities such as the ionisation balance and power loss to be calculated at magnetic fusion densities where the low density limit is not valid.

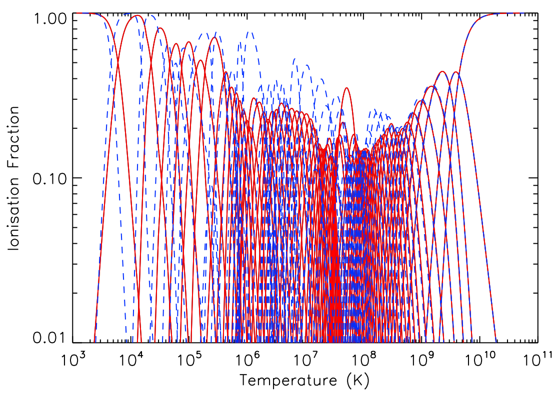

Figure 1. Comparison of calculated ionisation fractions for Tungsten using the Pütterich et al. [2] (red solid) and Foster [3] (blue dashed) recombination rates and Loch et al. [1] ionisation rates in the low electron density limit. From left to right, W^{0+}-W^{74+}.

References

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