

R-matrix excitation/ionization calculations for tungsten in support of magnetically-confined plasma diagnostics

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The collaboration between Queen's University and Auburn University has ensured that the relativistic atomic structure, electron-impact excitation/ionisation for neutral Tungsten and near-neutral ion stages may be validated against various collisional-radiative (CR) models and more importantly the observed spectra from the Compact-Toroidal Hybrid (Auburn University) and the DIII-D tokamak (General Atomics).

From the electron-impact excitation perspective, the Maxwellian-averaged excitation rates for neutral tungsten [1] are available in the literature, and shall be presently available within the well-known adf04 file format utilised by the ADAS consortium. For singly ionised tungsten, an 800 level model is underway and should be available by the end of the year.

For electron-impact ground and metastable ionisation the path forward is less clear. There are various non-perturbative calculations including a ground state ionisation configuration-averaged time-dependent close-coupling (TDCC) [2] calculation and a ground and metastable ionisation calculation employing the R-matrix with pseudo-states method. Even though initial comparisons between methods is reasonable, preliminary collisional-radiative calculations reveal that the total effective ionisation rate is dominated by highly-excited state ionisation rather than the ground state and first few meta-stables. Therefore SXB [3] ratios which are dependent on the effective ionisation rate will inevitably be a hybrid of explicitly calculated ground state and metastable ionisation and an empirical formula such as the ECIP (Exchange-Classical-Impact-Parameter) method.

1. R. Smyth *et al.*, *Phys. Rev. A* **97**, 052705 (2018)
2. M. S. Pindzola *et al.*, *J. Phys. B* **50**, 095201 (2017)
3. K. Behringer, *Plasma Phys. Control. Fusion* **31**, 2059 (1989)

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