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X-ray spectroscopy of Ne-like W in fusion plasmas

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Measurements of plasma parameters in the core of magnetic fusion devices represent a challenging task. Expected emission of x-ray lines of highly charged ions of W will be used in ITER or DEMO for derivation of electron and ion temperature, plasma rotation and finally the plasma control. In spite of considerable efforts to design the x-ray instruments operating in extreme harsh environment of future plasma devices [1], the accurate modelling of such spectra is still far from been complete [2].

The aim of this work is to provide the accurate effective rate coefficients for the lines in the spectral region of 1.35 Å to 1.5 Å of the contributing charged stages of W necessary in plasma modelling. The synthetic spectra are decomposed in contribution from Mg-, Na-, Ne-, F-, and O-like ions. This work provides probably the most complete set of atomic data for interpretation of the future X-ray spectra. Indeed, whereas the Ne-like ions are in general responsible for the line formation at the core of plasma devices, e.g., in the temperature range of 15 – 25 keV, the contribution from Na- and F-like ions remains considerable. We demonstrate here an overlooked impact of inner-shell ionization of Na-like W ions on the line formation of some of Ne-like lines. The intensity of some of the lines increase by up to 30 % which challenge the selection of the X-ray line to be measured in ITER or DEMO.

The calculations were performed with the collisional-radiative model NOMAD [3] using the FAC code [4] calculations of elementary atomic processes such as electron-impact rates, radiative and autoionization rates, etc. The model includes about 103 - 104 levels in each ion. We identified 51 lines in this interval which we describe in terms of effective rate coefficients of excitation Q^{exc}, recombination Q^{rec} and inner-shell ionization Q^{ion}:

$$I(T)\lambda \propto N_e N_{[Ne]} Q^{exc}(T) + N_e N_{[Na]} Q^{ion}(T) + N_e N_{[F]} Q^{rec}(T), \qquad (1)$$

where T is the electron temperature, I is the line intensity, λ, is the wavelength corresponding to the specific bound-bound transition, $N_{[He]}$, $N_{[Na]}$ and $N_{[F]}$ are the fractions of the Ne-, Na- and the F-like W ions, respectively. The tabulated values of fit results for the effective rate coefficients are presented. The errors of such decomposition remain on the order of 1 % and below in comparison to exact calculations and should provide a reliable basis for integrated plasma modelling of X-ray spectra from W ions.

References

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