§14. Collisional-Radiative Modeling of W^{27+}

Ding, X.B., Murakami, I., Kato, D., Sakaue, H.A.,
Koike, F. (Kitasato Univ.),
Dong, C.Z. (Northwest Normal Univ.)

Background. Tungsten (W) attracts research interest because it is a good candidate for the divertor or wall material in the next generation magnetic confinement fusion reactors due to its favorable properties. In the ASEDX Upgrade, the Ni-like W^{46+} to Kr-like W^{38+} ions were expected to be observed in the central plasma region and Rb-like W^{37+} to Sn-like W^{24+} ions were expected in the outer plasma region. It can be expected that the W^{26+} and W^{27+} ions will be abundant in the outer region of ITER as in ASEDX Upgrade.

Theory. The emission intensity (I_{ij}) of a specific transition from upper energy level i to lower energy level j of an atom in the plasma is proportional to the product of the radiative decay rate (A_{ij}) and population density (n_i) of the upper level i, i.e.,

$$I_{ij} \propto n_i A_{ij}. \tag{1}$$

where n_i can be obtained by solving the collisional-radiative rate equation:

$$\begin{aligned}\frac{dn_i}{dt} &= \sum_{j<i} C(j,i) n_e n_j \\ &- \left\{ \left[\sum_{j<i} F(i,j) + \sum_{j<i} C(i,j) + S(i) \right] n_e \right. \\ &\left. + \sum_{j<i} A(i,j) \right\} n_i \\ &+ \sum_{j>i} [F(j,i) n_e + A(j,i)] n_j.\end{aligned} \tag{2}$$

The radiative transition, collisional (de)excitation and ionization processes are included in the present calculation, while the radiative and dielectronic as well as three body recombination processes are not included because these processes only slightly affect the population of the low-lying levels that are relevant to the present spectrum. All the necessary atomic data were calculated by using relativistic configuration interaction method with FAC code.

Results and discussion. The synthetic visible spectrum of W^{27+} ions are given in Fig. 1, while the electron density dependence of the intensity ratio both in EBIT and fusion plasma are given in Fig 2 and 3. It provides a possible way to diagnose the fusion plasma[1).

1) Xiaobin Ding et.al., Plasma and Fusion Research, (2012) submitted

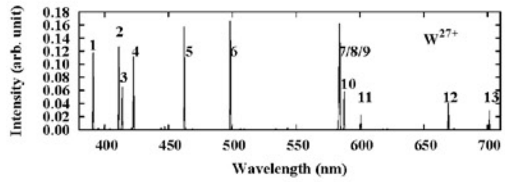

Fig. 1: The synthetic spectrum of W^{27+} ions in optical region with $n_e = 10^{10} cm^{-3}$ and $E_e = 830eV$, the electron distribution were assumed to be in mono-energy like in EBIT.

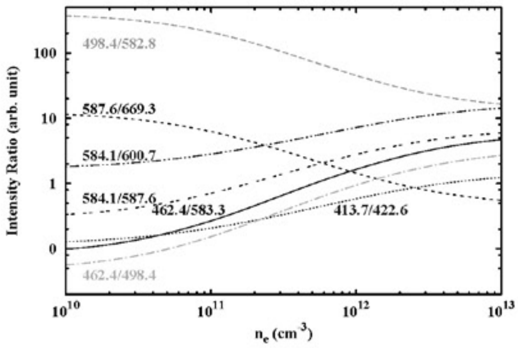

Fig. 2: Electron density dependence of the intensity ratio in optical region in EBIT environment($E_e = 830eV$ with electron distribution were assumed to be mono-energy).

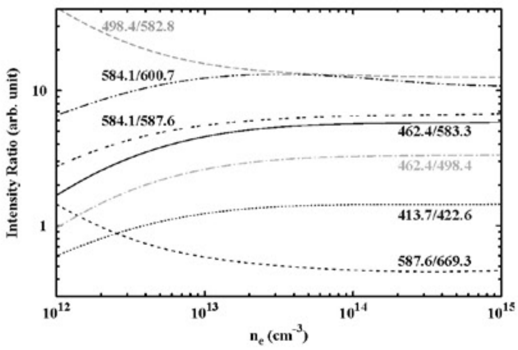

Fig. 3: Electron density dependence of the emission line intensity in optical region with $T_e = 1KeV$, the electron distribution were assumed to be Maxwellian like in fusion plasma.