

Polarization of the strongest $nf \rightarrow 3d$ ($n = 4, 5, 6$) radiative lines emitted from tungsten ions following EIE and DR processes

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Synopsis Electron-impact excitation and resonant electron capture cross sections to the specific magnetic sublevels of highly charged Ni-like to Ge-like tungsten ions have been calculated systematically by using a fully relativistic distorted-wave method. And these magnetic cross sections have further been employed to obtain the degrees of linear polarization of the corresponding strongest $nf \rightarrow 3d$ ($n = 4, 5, 6$) x-rays. We compare polarizations of the same lines but from the above two different processes for the first time. It has been found the polarizations following both the both processes are totally different. It is expected that the obvious differences between the polarizations can be used to distinguish the formation mechanism of the corresponding lines.

Tungsten, because of its high melting point, low sputtering rate and retention of tritium, has been used as plasma-facing materials in several magnetic fusion devices and is the leading candidate material within the divertor region of the International Thermonuclear Experimental Reactor (ITER) tokamak[1]. Electron-impact excitation (EIE) and dielectronic recombination (DR) of tungsten are the most essential atomic processes in the plasma. A systematical study on the cross sections of these processes is absolutely necessarily for the present fusion experiments and the modeling of plasma properties. Furthermore, the degree of linear polarization of radiation emitted from the unequally populated magnetic sublevels can provide a detailed knowledge about their excitation dynamics processes and has been recognized as an important diagnostic tool to characterize plasmas anisotropy.

In the present work, the target ion and the continuum electron wavefunctions are generated by the codes GRASP92 [2] and RATIP [3] based on the MCDF method. The EIE and DR cross sections between the individual magnetic sublevels are calculated by using the codes REIE06 [4] and REDR05 [5].

The degrees of linear polarization of $nf \rightarrow 3d$ ($n=4,5,6$) emission lines from EIE processes change in a range of 0.19-0.38 within five times that of the threshold energies for Ni-, Zn-, and Ge-like tungsten ions. And for Cu- and Ga-like tungsten ions, the degrees of linear polarization of $nf \rightarrow 3d$ emission lines change among the range of 0.09-0.21 within the same energy

range. For DR process, the degrees of linear polarization of these radiative lines are quite different for different tungsten ions (see Table 1).

This feature is interesting and can reveal the polarizations of the lines are from the different formation mechanisms. It is expected that the obvious differences between the polarizations can be used to distinguish the formation mechanism of the corresponding lines. Moreover, because EIE play a key role in hot and dense plasmas and DR dominate in low-density plasmas which are cooled and recombining by capturing continuum electrons, the specific plasmas conditions could be assessed by using these polarizations.

Table 1. The polarizations of the corresponding emission lines following DR processes of W^{45+} to W^{42+} ions.

Transition	Cu	Zn	Ga	Ge
$5f_{7/2} \rightarrow 3d_{5/2}$	0.6	0.98	0.6	64
$5f_{5/2} \rightarrow 3d_{3/2}$	0.6	0.91	0.6	49
$6f_{7/2} \rightarrow 3d_{5/2}$	0.6	0.97	0.6	42
$6f_{5/2} \rightarrow 3d_{3/2}$	0.6	0.89	0.6	23

References

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