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Theoretical study of W^{25+} spectra

G. Gaigalas[1], **A. Alkauskas, P. Rynkun, R. Kisielius, A. Kynienė, S. Kučas, Š. Masys, G. Merkelis, V. Jonauskas**

Institute of Theoretical Physics and Astronomy, Vilnius University, A. Goštauto 12, 01108 Vilnius, Lithuania

Synopsis Analysis of energy levels and radiative transition probabilities for W^{25+} ion is performed using multiconfiguration Dirac-Fock method.

Spectra from tungsten ions are widely studied due to plans to use tungsten as armour material in the divertor region of fusion reactors. Various tungsten ions contribute to the radiation from fusion plasma. On the other hand, emission from plasma in electron beam ion traps (EBIT) is limited mainly to few ionization stages controlled by electron beam energy.

The objective of the present work is to study energy levels and radiative transition probabilities for W^{25+}. The main focus is directed to the emission in spectral range 4-30 nm where intensive radiation of tungsten ions has been theoretically and experimentally investigated.

Spectra of this ion have been registered at the Berlin EBIT [1]. Theoretical treatment of the ion is complicated by the presence of an open f shell. For ions with configurations having open f shells, correlation effects may play crucial role due to the mixing of large number of levels. Relativistic effects with quantum electrodynamic corrections have to be taken into account to provide accurate wavelengths and radiative transition probabilities for highly charged ions. Study of energy levels and electric dipole, quadrupole and octupole as well as magnetic dipole and quadrupole transitions is performed using multiconfiguration Dirac-Fock method implemented in GRASP2K code [2].

Energy levels of 22 lowest configurations for the W^{25+} ion are shown in the figure 1. Total number of configuration state functions included in calculations amounts to 13937. The lowest configuration of the ion is $4f^3$. Thus the first excited configuration $4f^2\,5s$ can decay only through weak electric octupole transitions to the ground configuration. Electric dipole transitions are opened after configuration mixing is taken into account. However, they are some five orders of magnitude weaker than other transitions from $4f^25l$ $(l = 1, 2, 3, 4)$ configurations.

Previous investigation demonstrated that transitions from excited $4d^94f^4$ and $4f^25d$ configurations to the ground $4f^3$ configuration are responsible for strong emission lines of W^{25+} ion at about 5 nm [3]. However, calculated probabilities of $4f^25d \rightarrow 4f^3$ transitions are by one order weaker than probabilities of $4d^94f^4 \rightarrow 4f^3$ transitions.

Region of 10-30 nm is covered by lines which originate from $4f^25g \rightarrow 4f^25f$, $4f^25f \rightarrow 4f^25d$, $4f^25d \rightarrow 4f^25p$ and $4f^25p \rightarrow 4f^25s$ transitions in W^{25+}.

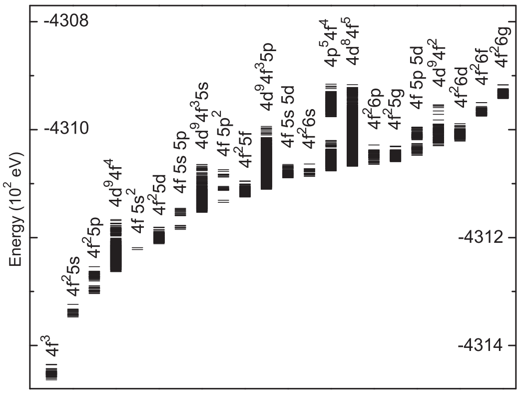

Figure 1. Energy levels of 22 lowest configurations in W^{25+}.

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[1]E-mail: Gediminas.Gaigalas@tfai.vu.lt