Competition between radiative and Auger decay processes of doubly excited Li-like C, N and O ions

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Synopsis We performed charge exchange collision experiments of metastable He-like C, N and O ions ($1s2s\ ^3S_1$) with neutral target gases, and observed soft X-rays from doubly excited Li-like C, N and O ions produced by single electron capture. These emissions corresponded to $1s^22s\ ^1S_0$ - $1s2s\ (^3S_1)\ np$ transitions according to calculations for transition energies by the Cowan code.

Radiative and Auger transitions are dominant and competitive decay processes of doubly excited and inner-shell excited states of atoms and molecules above their ionization potentials. These two processes have attracted much attention, because X-rays and Auger electrons from the superexcited states are of great importance for diagnostic of fusion and astrophysical plasmas [1], investigation of decay dynamics of molecules [2] and radiation induced damage on DNA [3]. Now there are very few papers about the radiative decay of superexcited atoms of light elements, because the Auger decay is much faster than the radiative decay in the light atoms.

The doubly excited states can be produced by double electron capture in atomic collisions. We produced doubly excited Li-like C, N and O ions [$1s2s\ (^3S_1)\ nl$] by single electron capture between metastable He-like ions ($1s2s\ ^3S_1$) and He or O_2 gas. Resonance and inter-combination transitions ($1s^22s$ - $1s2snp$) were observed by a grazing incidence spectrometer and a silicon drift detector (SDD). In order to identify spectral peaks, we calculated transition energies and rates of the Li-like ions by the Cowan code.

Table 1 shows calculation results of the Li-like oxygen ion by the Cowan code. In our experimental condition, the resonance transitions (^2S - ^2P) were mainly observed due to their high decay rates. Figure 1 shows soft X-ray spectra of the Li-like oxygen ions observed by the SDD. Two peaks at approximately 560 and 640 eV corresponds to radiations from the oxygen ions. A broad tail in low energy region is background signal derived from the SDD. Chen *et al*. calculated the Auger and radiative decay rates of Li-like C, N and O ions, and it was found that the Auger decay rate was only one order of magnitude higher than the radiative decay rate in the Li-like ions [4].

We discuss the competition between the radiative and Auger decay processes in the doubly excited Li-like C, N and O ions by comparing observed spectra with calculation results of each radiative and Auger decay rate.

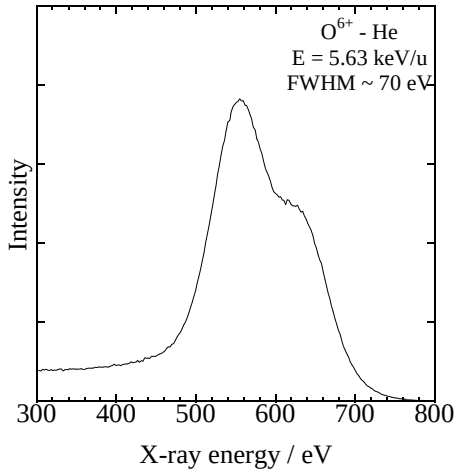

Figure 1. Soft X-ray spectrum of Li-like oxygen ions observed by the SDD. Energy resolution is approximately 70 eV.

Table 1. Calculated transition energies and radiative decay rates for states of $1s2s\ (^3S)\ np$ configurations of Li-like oxygen ion.

Lower state	Upper state		Energy (eV)	Rate (s^{-1})
$1s^22s\ ^2S$	$1s2s(^3S)2p$	$^4P_{1/2}$	554.0	5.17E+07
		$^4P_{3/2}$	554.0	2.61E+08
		$^2P_{1/2}$	567.8	6.24E+11
		$^2P_{3/2}$	567.8	1.15E+12
	$1s2s(^3S)3p$	$^4P_{1/2}$	640.1	4.11E+07
		$^4P_{3/2}$	640.1	2.11E+08
		$^2P_{3/2}$	641.6	2.43E+12
		$^2P_{1/2}$	641.6	1.22E+12

References

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