XXVIII International Conference on Photonic, Electronic and Atomic Collisions (ICPEAC 2013) IOP Publishing
Journal of Physics: Conference Series **488** (2014) 062023 doi:10.1088/1742-6596/488/6/062023

Indirect processes in x-ray line emissions of $5f \rightarrow 3d$ transitions of highly charged gold ions

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Synopsis We present an experiment for the $5f \rightarrow 3d$ transitions of highly charged gold ions with an electron beam ion trap. The indirect process contributions for these transitions were investigated experimentally.

To understand the radiation properties, energy deposition, energy balance, etc. of hot plasmas, predicting the correct charge state distribution is substantially important. It is complex for the charge state calculations of hot plasmas which are in nonlocal thermodynamics equilibrium. In particular, there are the most significant discrepancies in the calculations for high-Z element which is of the conditions of typical laser-produced plasmas. For example, in the inertial confinement fusion researches, a gold hohlraum irradiated by intense lasers is usually used to convert lasers to x-ray radiation [1]. The analysis of these high-density experiments was complicated by the transient nature of the laser-produced plasma and the many competing atomic processes present in these plasmas. However, electron beam ion trap is an ideal facility to disentangle the basic atomic physics processes due to the plasmas with a low density [2, 3].

In the present work, x-ray spectral emissions were measured for the $5f \rightarrow 3d$ transitions of highly charged gold ions which charge states are from Cu- to Se-like with Tokyo electron beam ion trap [4]. The highly charged gold ions in Tokyo-EBIT were produced by successive electron collisional ionization of gold atoms injected by an effusion cell. To investigate the direct and indirect process contributions to the excited state populations, two settings for the electron beam energy were used. One was a fixed energy at 3.5 keV which corresponds to the direct process, the other was energy scanned from 1.98 to 3.08 keV. A flat crystal spectrometer with a measuring range from 3.24 to 3.36 keV was used to obtained the x-ray spectra, and the experimental results are shown in Fig.1. The spectra have been identified and labeled for the different charge state ions. The spectra (a) and (b) in Fig.1 have a large difference. Spectra (a) is from direct electron impact process, whereas (b) is from the indirect electron impact processes.

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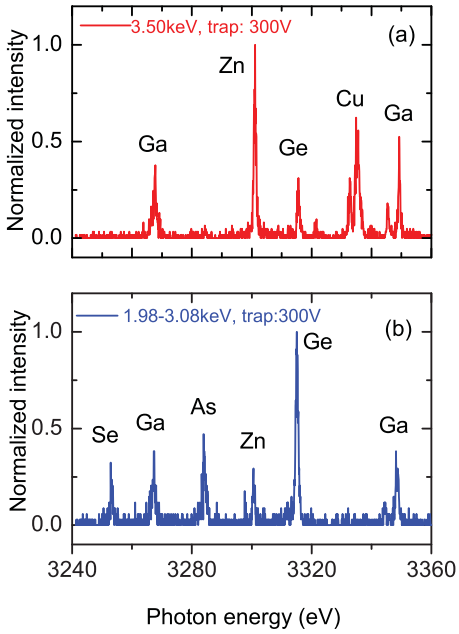

Figure 1. X-ray spectra of $5f \rightarrow 3d$ transitions of highly charged gold ions.

The indirect processes may include dielectronic recombination, multi-step excitation, etc. To investigate the indirect process contribution to the x-ray emissions, an analysis and spectral simulation work is ongoing. We present the comparison between the experiments and the simulation calculations.

References

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