§10. Auger Decay Processes in Highly Charged Ion-Atom Collisions

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In the present experimental work we have investigated multi-electron (up to 4) transfer processes in I^{q+}(q = 10, 15, 20) + Ne, Ar, Kr and Xe collisions at keV/u energy range. Using the coincidence technique between the charge-selected projectile and recoil ions, the branching ratios between Auger and radiative channels have been measured in decay processes of multiply excited states formed through multi-electron transfer.

We consider the following multiple electron capture processes

$$I^{q+} + B \rightarrow I^{(q-j)**\cdots}(n,n',\cdots) + B^{j+}$$
$$\rightarrow I^{(q-i)+} + B^{j+} + (j-i)e^- + h\nu + h\nu'$$

n,n'... : the principal quantum number

We determined the branching ratios for the decay of multiply-excited ions from the coincidence measurement of scattered ion and recoil ion. The branching ratios *P(j,j-i)* for the decay of multiply-excited ions by the emission of (*j*-*i*) electrons after *j*-electron transfer is defined by

$$P(j,j-i) = \frac{\sigma^j_{q,q-i}}{\sum_i \sigma^j_{q,q-i}}.$$

The electrons are transferred to higher excited levels *n* of ions from target atoms as the ion charge number increases. We calculated the electron transfer levels *n* in each collision by ECBM, and the branching ratios are discussed in average value $<n>$.

In figure, the principal quantum number $<n>$ dependence of the branching ratios is shown in each *j*-electron excited state. Here, we plotted the branching ratios with $-<1/n^2>$ so that an ionization limit could be recognized. And all our experimental data in I^{q+}+B collisions (*q*=10, 15, 20 B=Ne, Ar, Kr, Xe) are shown. And then, we show the calculated threshold $<n>$ of *P(j,j-i)* Auger decay which is energetically allowed, respectively, in this figure.

In the case of the doubly excited state (fig.(a)), if the highly charged ions bound the electrons to the higher excitation levels than *P(2,1)* threshold ($n \cong 5.7$), the single Auger decay is dominant (90%) and the branching ratio hardly changes in such ion charge number q=10~20.

In the case of triply excited state (fig.(b)), when the three electrons were bound to comparatively inner shells ($5.3<n<7$) of the ion, the excited ions decay with emitting one electron. However, when the electrons were transferred to the higher levels than *P(3,2)* threshold level ($n \cong 6$), the single Auger decay processes decrease as the double Auger decay processes increase gradually. Moreover, when the three electrons were transferred to high-excited states (Rydberg state *n*=8,9,10---), the double Auger decay ratio becomes about 80%.

In the same way, in the case of the 4-electrons excited state (fig.(c)), the double Auger decay processes increase as the single Auger decay processes decrease from around *n*=5~6. The double Auger decay processes become dominant around *n*=6 and the triple Auger decay channel is opened at *n*=6.3 which is *P(4,3)* threshold. Then, the ratios of double and triple Auger decay are reversed near *n*=8. And when the three electrons were transferred to high-excited states (Rydberg state *n*=10,11---), the triple Auger decay ratio becomes dominant (70%).

The present observation of branching ratios suggests that the Auger decay processes are characterized by principal quantum number *n* of the excitation level and doesn't depend on the ion charge number *q* so strongly in such ion charge number (*q*=10~20).

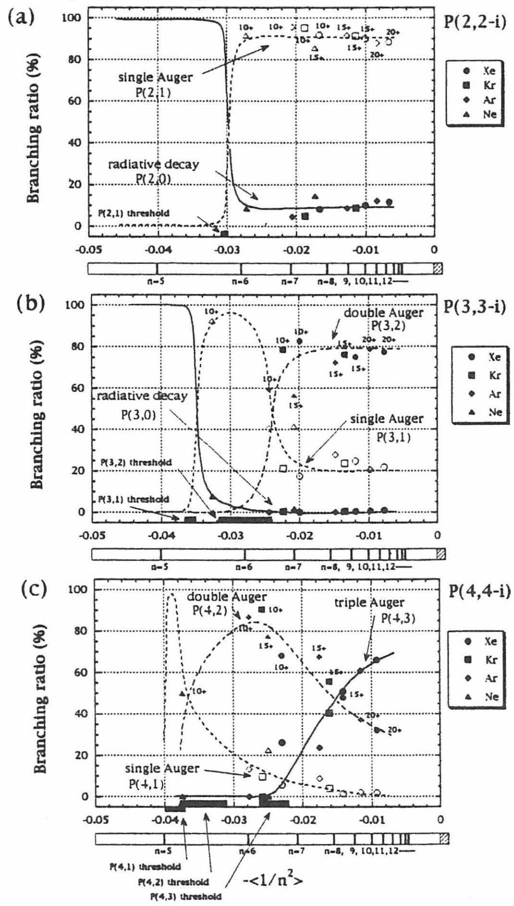

Figure. $-<1/n^2>$ dependence of the branching ratios *P(j,j-i)*. *n* is the calculated principal quantum number of excitation level by ECBM.