§24. Spectroscopic Measurement of Double Electron Capture Process in Collisions of Alpha Particle with CO Molecule at TPD-II Device

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Double electron capture process between alpha particle and CO molecule:

$He^{2+} + CO \rightarrow He^{*}(nl, n'l') + (CO)^{2+}$

has been found to have a very large cross section ($10^{-15}cm^2$ or more) in collisions at low energies (below 1eV). To see the product-state distributions, We observed the He I ($np\ ^1P \rightarrow 1s^2\ ^1S$) photon emissions when helium plasma is in contact with carbon monoxide gas. The experiment has been performed at the TPD-II plasma machine, which produces a quiescent DC helium plasma (an electron density of 10^{14} cm^{-3} and an electron temperature of several eV). High density He plasmas are produced with a discharge current of 100 A.

In order to observe a electron-capture collision, CO gas has been introduced into the helium plasma by gas puffing system with a piezo-valve for a duration of 10 ms. A 2m vacuum UV monochromator was used to observe the He I photon emission.

Figure 1 shows the temporal behavior of typical line intensities in He I ($np\ ^1P \rightarrow 1s^2\ ^1S$:n=2-11) lines after the gas injection.

When CO gas is introduced into the helium plasma, electrons in the plasma are immediately cooled down through inelastic collisions with the injected CO molecule. The He I (n=2,3,4,6,7,10,11) line intensities vanish immediately after the CO injection, because of the decrease in electron impact excitation rate. But He I (n=8→n=1) line intensity increases sharply. The increase in the intensity can be understood to show the product-state of neutral helium.

For single electron capture process:

$He^{+} + CO \rightarrow He^{*}(nl) + CO^{+}$,

it is known to have a small cross section at low energies ($10^{-16}cm^2$ at 1 eV). Thus this process can't contribute to the observed He I line emissions. The increase of the He I (n=5,9) is identified to be due to the spectral lines from the oxygen ions by dissociated CO molecules.

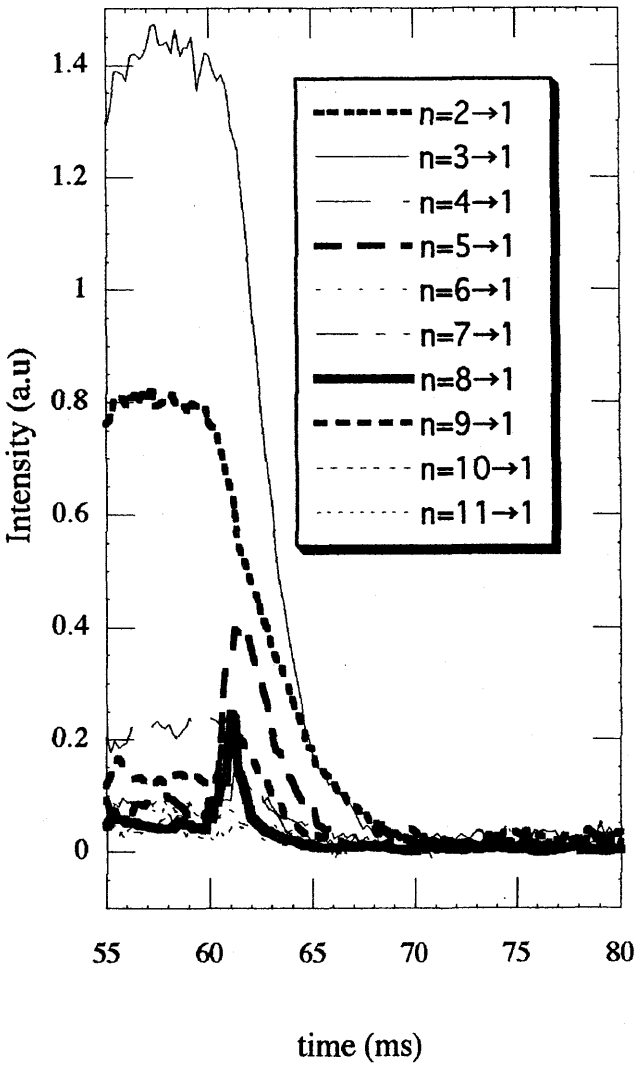

Fig. 1. Time evolutions of the intensity of the He I ($np\ ^1P \rightarrow 1s^2\ ^1S$:n=2-11). CO gas is injected into the He plasmas at the time of 60 ms.

References

1) Sato, K. et al. : J. Phys. B **27** (1994) L651.