## §17. Observation of Population Inversion in He I due to a Double Electron Capture Process

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Investigations of recombination processes in high density plasmas were started after remodelling of the TPD-II device for higher discharge current operation. Observations of inverted population density due to a double electron capture has been performed for He plasma in contact with $H_2$ molecular gas. The following charge transfer process into a selected state,

$$He^{2+} + H_2 \dashrightarrow He^*(1s\,3l) + 2H^+ \qquad (1)$$

is found to have a very large cross section ($\geqq 10^{-15}cm^2$) in low collision energies($<1eV$), due to an orbiting effect and accidental resonance. In order to observe a double electron capture process by spectroscopic methods, a gas puffing system with a piezo valve was installed. A pulsed supersonic $H_2$ molecular gas has been introduced into the He plasma for a duration of 12.5ms. 2m VUV and 75cm visible monochromators have been used to observe He I resonance spectra ($np^1P \dashrightarrow 1s^1S$ n=2,3,4,5). Figure 1 and 2 show typical results of the time evolution of the population density under the discharge current 120A, the discharge voltage 130V, magnetic flux density 0.2T, He gas flow rate for discharges 150cc/min and 270cc/min respectively. Apparently from Fig.1, population density of only n=3 appears anomalous enhancements immediately after a $H_2$ gas injection and population inversion between $2p^1P$ and $3p^1P$ is obtained,. The reason of the enhancements of He I n=3 is concluded as the process of eq. (1), because its cross section is very large and a cross section of the other single electron capture process, such as

$$He^+ + H_2 \dashrightarrow He^*(nl) + H_2^+ \qquad (2)$$

is small ($<10^{-18}cm^2$) at low collision energy.

On the other hand, Fig. 2 shows the unexpected results. In contrast to the temporal behaviors of populations in FIg.1, population densities of low excited states increase quickly. One possible explanation would be considered by the following processes. That is, firstly excitation of vibrational states of hydrogen molecule,

$$H_2^{v=0} + e \dashrightarrow H_2^v + e \qquad (3)$$

secondary, double electron charge transfer

$$He^{2+} + H_2^v \dashrightarrow He^*(1s, n=2,3,4,5) + 2H^+ \qquad (4)$$

The injected hydrogen molecules are excited into vibrational states by electron or ion impact. Next, these vibrational excited $H_2^v$ would collide alpha particles. Also in this case, the inverted population has been observed.

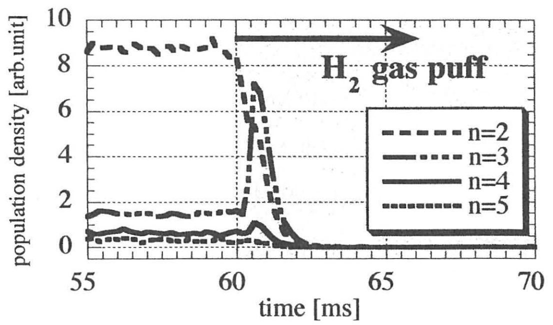


Fig.1 Time evolution of He I population density under He gas flow rate 150cc/min.

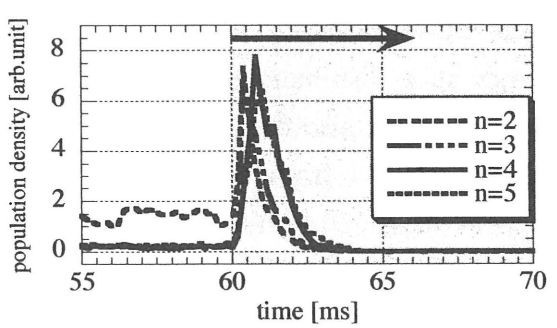


Fig. 2 Time evolution of He I population density under He gas flow rate 270cc/min.