22P090-P

Measurement of the ionization cross section for a negative Au ion beam with the tandem accelerator

タンデム加速器を用いた金負イオン電離断面積の測定

Tomoaki Shinobu[(1)], Akira Taniike[(1)], Syo Mochizuki[(1)], Takeshi Ido[(2)], Masaki Nishiura[(2)], Akihiro Shimizu[(2)], Yuichi Furuyama[(1)], Akira Kitamura[(1)]

忍 友彰[(1)]，谷池 晃[(1)]，望月 翔[(1)]，井戸 毅[(2)]，西浦正樹[(2)]，清水昭博[(2)]，古山雄一[(1)]，北村 晃[(1)]

[(1)]*Maritime Sciences, Kobe University*

5-1-1, Fukae Minami-machi, Higashinada-ku, Kobe 658-0022, Japan

神戸大学大学院・海事科学研究科 〒658-0022 神戸市東灘区深江南町5-1-1

[(2)]*National Institute for Fusion Science*

322-6 Oroshi-cho, Toki 509-5292, Japan

核融合科学研究所 〒509-5292 岐阜県土岐市下石町322-6

In this study, we investigated the fundamental process of heavy ion beam generation by our tandem accelerator. The gas thickness in the gas cell was calibrated by the measurement with using BARATRON, the conductance calculations, and the reference experiments with known cross sections. The ionization cross sections of the negative Au ion was obtained with the beam attenuation method, and the energy was below 1000 keV.

1. Introduction

A heavy ion beam probe (HIBP) method is a diagnostics method to measure the plasma potential directly. On HIBP system for large helical devices (LHD) which is one of the plasma confinement devices, a tandem accelerator of 3 MV is used. A beam of 1.5 MeV Au$^+$ ions has been used for diagnostics in plasma confined magnetic field of 1.5 T (6 MeV is for 3 T) [1]. Recently HIBP has measured the potential of the plasma whose electron density is about 0.1×10^{19} cm^{-3}. In order to apply it to a high-density plasma, it is necessary to increase the beam current. When an Au$^-$ ion collides with an atom in the gas cell of the tandem accelerator, the phenomena such as charge exchange, ionization, electron capture, and scattering occur. Therefore, in order to investigate the fundamental process of the heavy ion beam generation in this study, we obtained the total ionization cross section of Au$^-$ ion using the ion beam current detection system at the 0 degree beam line of our tandem accelerator.

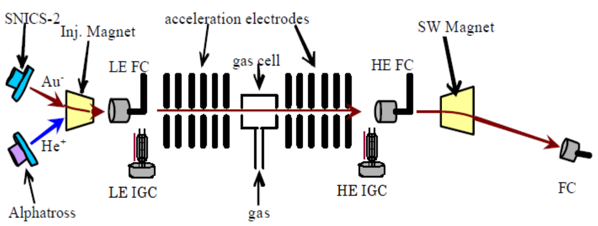

Fig. 1. Schematic view of the tandem accelerator system at Kobe University.

Figure1 shows Schematic view of the tandem accelerator system at Kobe University.

2. Calibration of the gas thickness in a gas cell

In order to calibrate the gas thickness in the gas cell, first we investigated the pressure of central part of the gas cell. Fig. 2 is Schematic view of the gas cell part.

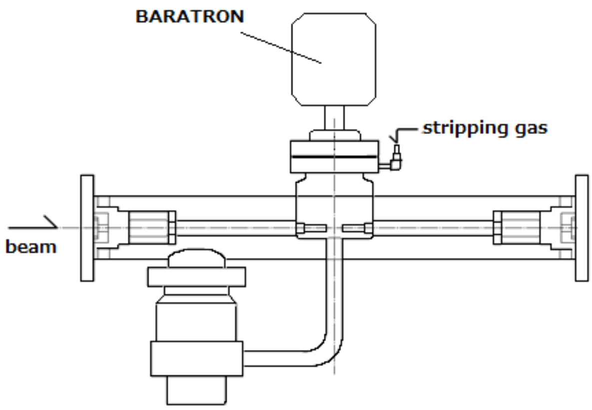

Fig. 2. Schematic view of the gas cell.

In order to measure the pressure of the central part of the gas cell directly, the pressure transducer (BARATRON) was installed in the gas cell upper part of the high-pressure terminal. When BARATRON is installed, it is not easy to measure the pressure in the tandem operation. Then, the relationship between of BARATRON and the ionization gas gauge controller (HE IGC) installed in outside of accelerating tube was investigated for some kind of gas. Because HE IGC is placed at ground potential, it can measure the pressure in the operation, and the pressure of the gas cell central part is determined by the value. To take into account the pressure distribution in the gas cell, conductance calculations conducted. From these results, the gas thickness in the gas cell corresponding to the gas species was calibrated. Details of the experiments is done in a poster presentation.

3. Measurement of the ionization cross sections for a negative Au ion beam

In the rate equation taking into account of Au^-, Au^{0+}, Au^{1+}, Au^{2+}, Au^{3+} and Au^{4+}, $\sigma_{0,-1}F^0$ becomes negligible in the case of the small gas thickness, and the fraction of Au^- can express in the following approximation.

$$F^- = e^{-(\sigma_{-1,0}+\sigma_{-1,1}+\sigma_{-1,2}+\sigma_{-1,3}+\sigma_{-1,4})x} \quad . \qquad (1)$$

The fraction of Au^- decreases exponentially with increase in the gas thickness. The data of Au^- currents for some energy were fit by the following exponential functions.

$$I = I_{LE} \exp(-\sigma x) \quad . \qquad (2)$$

Here, I is the current measured in experimental chamber, I_0 is the current measured by LE FC, σ is the total ionization cross section, x [cm^{-2}] = nl is gas thickness.[2]

4. Result

In these experiments, Ar was used as stripping gas. Au^- beam was transported to the experimental chamber and it was focused on the FC in a detection chamber. Then, the pressure in the gas cell was changed and Au^- ion beam current was measured. Moreover, experiments were conducted for various impact energies of Au- ions. The results were shown in Fig. 2.

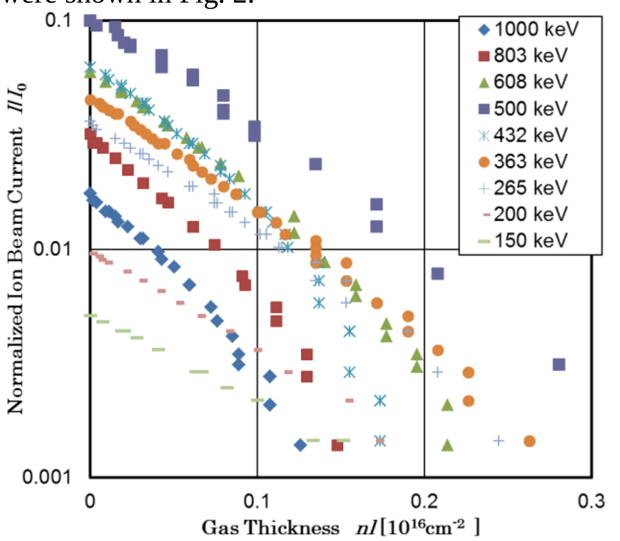

Fig. 2. Measurement for some impact energies.

The positive charged Au ions are increased with decreasing of Au^- ions. A value deviates from exponential curve because the positive Au ions are simultaneously measured as gas thickness becomes large. In each energy, There data is fit by equation(2) in the range of 0 - 0.1 × 10^{-16} cm^{-2}, and the total ionization cross sections of Au^- in each impact energy were determined. The results are shown in Fig. 3. Comparing the total ionization cross sections with that indicated in reference [3], our data in this experiment is somewhat small, but it is in agreement with less than 13%.

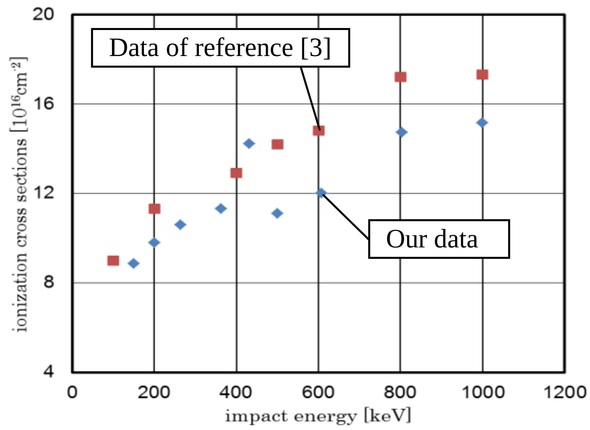

Fig. 3. Dependences of total cross sections and the coefficient on the impact energy.

5. Conclusion

Investigating the relationship between pressure measured by BARATRON and HE IGC, the absolute pressure inside the gas cell in operation was obtained, and the gas thickness in the gas cell was calibrated by the pressure of HE IGC. Moreover, using the gas thickness, the Au^- ion total ionization cross sections of various impact energies were obtained from the Au^- beam attenuation measurements. Although there are almost equal to the value of reference [2], our data is somewhat smaller. In order to determine the various cross sections in collision, in addition to the results presented in this study, measurements for the neutral particles and the positive ions are needed. [4]

References

[1] T. Ido *et al.*, J. Plasma Fusion Res. Vol.86, No.9 , pp.507-516(2010)

[2] M. Nishiura *et al.*, NIFS Research Report, NIFS Series 884(2008).

[3] M M Sant'Anna *et al*., Plasma Phys Control. Fusion, 51, 045007(2009)

[4] A. Taniike *et al.*,Plasma Fusion Res. 5, S2087(2010)