22P089-P

Charge Fraction Measurements for Au Ion Beams Generated by tandem accelerator
タンデム加速器で生成された金イオンチャージフラクションの測定

Akira Taniike(1), Tomoaki Shinobu(1), Syo Mochizuki(1), Takeshi Ido(2),
Masaki Nishiura(2), Akihiro Shimizu(2), Yuichi Furuyama(1), Akira Kitamura(1)
谷池 晃(1)，忍 友彰(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

The Heavy ion beam probe method is one of the methods of measuring the plasma potential, and the method can be useful to study a mechanism of plasma confinement. In this study the fundamental properties of the generation process of the charged heavy ion beams were examined. Charge fractions of Au ions were measured with a tandem accelerator at Kobe University. After Au^- ion whose energy was below 1 MeV was collided with atoms in a gas cell at high voltage terminal, the positive Au ions were generated. These ionization and recombination cross sections in collision of Au ions/neutral and target gas were estimated from the experimental results.

1. Introduction

The Heavy Ion Beam Probe (HIBP) method is a method of the plasma diagnostics, which measures plasma potential distribution. In HIBP method for Large Helical Device, a high energy Au^+ ion beam is injected into the LHD plasma, and the Au^{++} ions are detected. It is expected that the method is applied to the higher density plasma in future [1]. An enhanced Au^+ beam current is needed for the purpose. The LHD-HIBP system has a tandem accelerator with a gas cell which is a gas confinement system for charge stripping of ions.

Our tandem accelerator which has a gas cell can be used in preliminary experiments for enhancement of the Au^+ ion beam current. Measurements of the ratio of the ion beam currents for some charge state ions, i.e. charge fraction, can be conducted.

The measurement system of the ion beams in the present work, taking account of the atomic / molecular collision process in the gas cell, is available to obtain the physical value such as the ionization cross sections. Determination of the gas thickness is one of the most important items to obtain the cross sections. The results will be presented in a poster of 22P090-P.

2. Experimental Apparatus

In the present work tandem accelerator system at Kobe University has been used. The accelerator is of the pelletron type and the maximum terminal voltage is 1.7 MV. There are five beam lines at intervals of 15 degrees for the experiments such as the accelerator analyses or the ion beam irradiation. The ion beam is bended by a switching magnet (SW Mag.) to each beam line. Because mass of the Au atom is too heavy, the ions with energies of the order of MeV cannot be bent into the existing beam line. The maximum energy should be about 300 keV, and the incident energy of Au^- into the gas cell is 150 keV [2]. Therefore, an ion detection system with a small deflection angle was installed at 0 degree (straight beam line) [3]. The system is shown in Fig. 1. The system allows detection of the high energy Au ions.

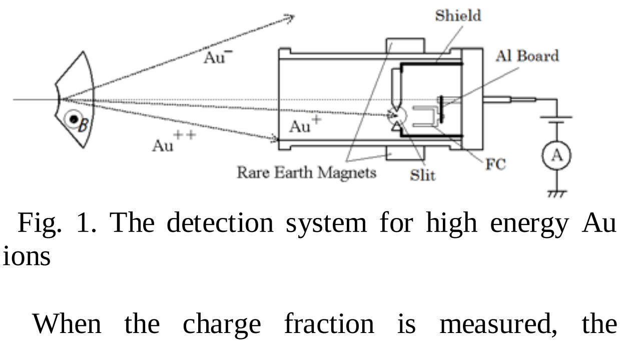

Fig. 1. The detection system for high energy Au ions

When the charge fraction is measured, the following attention is necessary. Because the bending angle of ions is small, non focused single charged ions, for example, are overlapping to the doubly charged ions. Consequently, the current of Au^{++} ion beam should be corrected for the spreading Au^+ beam current.

There is a restriction on selection of stripping gas species. When the terminal voltage is applied, a tube for transporting the stripper gas to the terminal sometimes suffers from high-voltage breakdown and SF_6 gas to insulate the accelerator columns is introduced into a stripper gas cell. In the case of Ar gas this phenomenon is avoided by raising the pressure of a gas cylinder to 1 MPa. But in the case of Ne, the phenomenon is caused even if the same treatment was made. In present work, N_2 gas was used as the stripper gas, because the gas has resistance to high voltage operation.

3. Results and Discussion

Au^- ions were generated by a Cs sputter type negative ion source and were injected into the tandem accelerator. N_2 gas was introduced as target (stripper) gas. The energy of Au^- ion at the gas cell was 500 keV, the terminal voltage was 479 kV. An attenuation curve of Au^- beam current as a function of the target gas pressure was obtained and is shown in Fig. 2. In the figure the horizontal axis indicates the pressure, P_{HE}, measured at the post-acceleration beam-duct, and is not calibrated to gas thickness. The Au^- beam current is normalized by the current measured at LE FC, which is the Faraday cup placed between the ion source and the tandem column.

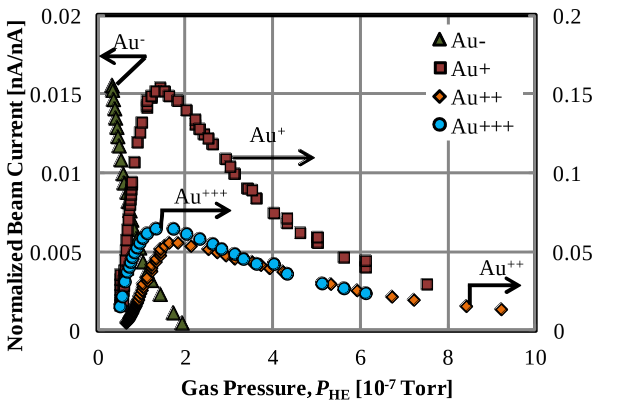

Fig. 2. Charge fractions for Au^-, Au^+, and Au^{++} beams as a function of gas pressure.

A current through SW Mag. was set so that the Au^+ ions could be detected. Then, the parameters of Einzel lens, Q-doublet lens, and so on was adjusted, so that the Au^+ beam current became maximum. The SW Mag. current was swept, and the energy (momentum) spectrum of the Au^+ beam was measured. The result is shown in Fig. 3, together with the results for Au^{++} and Au^{+++} using the same procedure.

It is shown in these results that the distribution of the Au^{++} ions was overlapped by that of the Au^+ ions. Therefore, when the gas pressure dependence of Au^{++} ion beam is measured, a correction in a beam current is needed. The same is true in the case with the Au^{+++} ion beam.

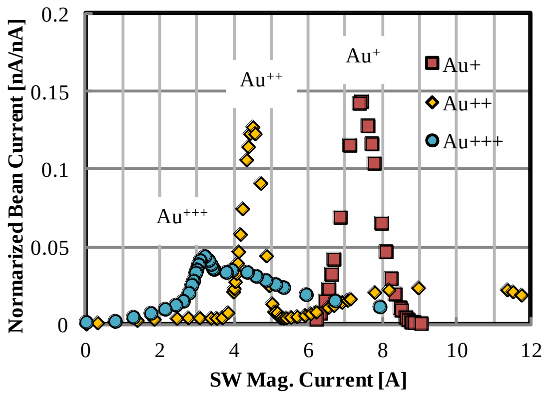

Fig. 3. Momentun spectra for Au^+, Au^{++}, and Au^{+++} ion beams.

The gas pressure dependences of Au^+, Au^{++}, and Au^{+++} ion beams are shown in Fig. 2, together with that of Au^-. The current was normalized by the current of LE FC and the charge state. Some cross sections can be deduced from these data and that of neutral particles. Since an experiment for the neutral particles was not conducted, some assumption is needed for obtaining cross sections. In our poster, an estimation of the cross sections will be presented in detail.

4. Summary

The Au ion beams were generated by charge-exchange collisions with N_2 gas introduced into the gas cell. The charge fractions of Au ions were measured in our tandem pelletron accelerator. The gas pressure dependence of some charge state ions was measured correctly by removing a influence of the overlapped other ions. In our poster, an estimation of the cross sections and the experiments for other gas and energy will be presented in detail.

References

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

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

[3] A. Taniike *et al.*, Rev. of the Faculty of Mar. Sci., Kobe Univ., No. 8, pp.47-58(2011).