Ion Storage in Kingdon Trap

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1. Introduction

Kingdon trap[1] has been used for many studies on collision interaction and spectroscopy of low energy single and multiply charged ions[2-4]. In comparison with rf quadrupole or Penning ion traps, Kingdon trap offers several advantages. Because of the simple structure, it is relatively easy to construct. Also it requires neither a large rf driving voltage nor a large magnetic field which may induce significant perturbations in the energy levels of the trapped ions. Kingdon trap is considered to be the best candidate of PHOBIS (Photon Beam Ion Source) for efficient ion extraction to produce an external beam, as suggested by Johnson et al.[5] at Brookhaven National Laboratory. As has been demonstrated in ref.[2], a voltage pulse on extraction grids can be used to produce a multiply charged ion beam for a variety of experiments.

In this paper we report some measurements of characteristics of a Kingdon trap for storage and extraction of Ar ions using a time of flight (TOF) mass spectrometer.

2. Experiment

Figure 1 shows a sketch of the Kingdon trap and theTOF spectrometer. All of these are contained in a stainless steel chamber evacuated by two turbo molecular pumps. The trap consists of a conducting cylinder coaxial with a metal wire and two end plates.

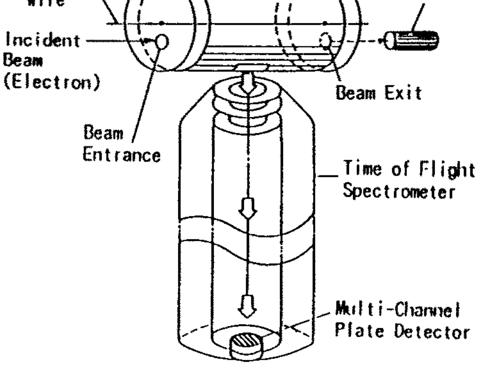

Fig. 1. Kingdon trap and TOF spectrometer

The end plates are insulated from the cylinder and the wire. The cylinder is at the earth potential. The central wire voltage (V_{CW}) and the end plates voltage (V_{EP}) can be defined independently. The cylinder of 25 mm diameter is 50 mm in length and the wire is 30 μm diameter gold plated tungsten. The electron beam is accelerated to 2 keV and collimated to 1 mm diameter and passes through the trap parallel to the wire and 5 mm apart from the center toward the TOF. The pulsed electron beam is obtained by applying a voltage pulse-d to the deflecting plate of the electron gun. The beam current is monitored by a Faraday cup.

With the wire at negative potential with respect to the cylinder, the ions produced by electron beam irradiation are confined about the central wire. The stored ions are analysed by applying a dump pulse of hight +100 V and width about 2 μs to the wire by using a pulse generator and extracting them to the TOF. The wire potential is raised at a time t after the cutoff of the electron beam pulse. A microchannel plate (MCP) is used for the ion detection of the TOF. The timing signal of the electron beam pulse and the ion detection signal from the MCP are used as the start and stop signals of the time to amplitude converter(TAC).

The target Ar gas is fed into the trap through a leak valve, and gas pressure was monitored continuously during the experiment. The target gas pressure was maintained within the range of 7.5 - 9.5×10^{-7} torr.

We have already searched the optimum condition for storage of Ar^{q+} (q=1,2,3) by changing systematically the V_{CW} and V_{EP}. The results are given in ref.[6].

3.Results and Discussion

Figure 2 shows a typical TOF spectrum of Ar ions where t= 100 μs, V_{CW}= -3V, V_{EP}= 6V and the pulse width of electron beam was 40 μs. In this figure the peak of Ar^{+} is reduced to 1/10. We can see that Ar^{q+} (q=1,2,3,4) ions are produced and trapped. Storage time (t) dependence of the ion yields of Ar^{q+} (q=1,2,3) was measured from t= 20 μs to 500 μs by 20 μs step where V_{CW}= -3V, V_{EP}= 6V and the pulse width of electron beam was 40 μs. The results are shown in fig. 3. The peak count of Ar^{4+} was apparent, as shown in fig. 2, but the intensity was so weak that the analysis

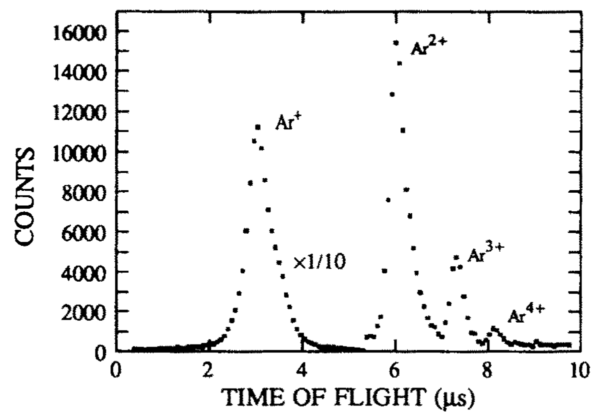

Fig. 2. TOF spectrum of Ar ions where t= 100 μs, V_{CW}=-3 V, V_{EP}= 6 V and the pulse width of electron beam is 40 μs. The peak of Ar^+ is reduced to 1/10.

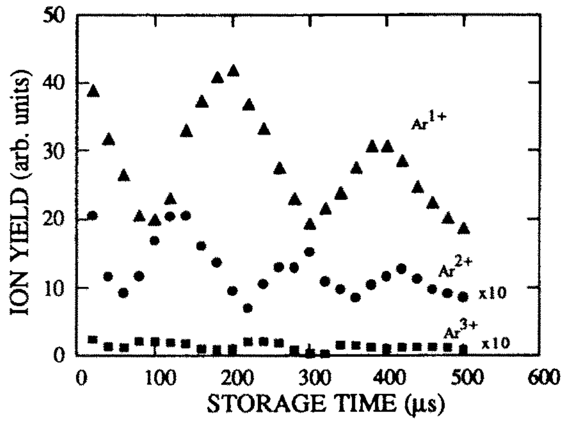

Fig. 3. Storage time (t) dependence of the ion yields of Arq+ (q=1,2,3) from t= 20 μs to 500 μs by 20 μs step, where VCW= -3 V, VEP= 6 V and the pulse width of electron beam is 40 μs.

could not be made. In fig. 3 the data are normalized by integrated beam current and averaged gas pressure during the experiment. Remarkable oscillation structures are found in the decay curves of ion yields for Ar^+, Ar^{2+} and Ar^{3+}. This means the periodical motion of the trapped ion cloud of each charge state about the central wire.

Taking account of this oscillation is very important when a Kingdon trap is used for a spectroscopy measurment of a metastable state of trapped ions whose life time is of the order of 1 ms, or the successive ionization of trapped ions in the PHOBIS.

Detailed analysis using computational calculation of the ion orbit is under way to investigate the periodical motion of trapped ion-group at each charge state.

References

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