Ejection test using an oscillating electric field from an RF ion-trap toward the generation of a slow RI atomic beam

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Manipulating atomic spin states is useful in a wide range of areas, which includes clarifying elucidating nuclear moments and applications in solid state physics. We are currently developing a device that generates spin-polarized radioactive isotope (RI) beams using an atomic beam magnetic resonance (ABR) method.[1)]

The ABR method combines a highly polarized beam by atomic spin selection (using a magnetic field gradient generated by a multipole magnet) and transitions between hyperfine splitting.[2)] A slow atomic beam at room temperature is required to utilize this method for RI beams. We are currently working on the offline development of a neutralizer that can generate a slow RI atomic beam. In this device, ions are trapped and reduced in energy using a linear RF ion trap and laser cooling. They are neutralized by blowing an electron-donator gas onto them; however, as soon as the trapped ions are neutralized, the atoms will scatter and cannot be transported as an atomic beam. The momentum of ions in the trap axis direction is increased using an oscillating electric field before applying the neutralization to overcome this technical difficulty. Thus, efficient transport would be possible. We report on an experiment to eject trapped ions using an oscillating electric field for Rb ions produced from a surface ionization Rb ion source.

Currently, the RF ion trap used in the neutralizer uses electrodes divided into five along the trap axis. A trap potential was formed by applying an RF voltage and a DC voltage to each electrode of this ion trap. The oscillating electric field was superimposed by applying a sine wave that changes very slowly ($\sim$1 Hz) to the DC voltage of each electrode. In this case, the potential of the electrodes at both ends was kept constant, and a swing potential was formed by shifting the initial phase of each electrode by $\pi/4$, thereby giving the ions momentum along the trap axis (see Fig. 1).

The amplitude of the oscillating electric field was set to 1.6 V, the initial phase was set to $-\pi/2$, $-\pi/4$, 0, $\pi/4$ and $\pi/2$ from the upstream side, and the voltage of the both end electrodes were set to 20 V.

After the swing for a particular number of the period, the number of ions ejected was counted by a channel electron multiplier (CEM) placed downstream of the RF trap by setting all RF and DC voltages to zero. This test was performed with a swing number of 0.25 to 20 in increments of 1/8 of a period. This measurement was repeated three times, and the average efficiencies as a function of the swing numbers are shown in Fig. 2. We achieved a maximum of $\sim$55% of the ion extraction, and found a periodic structure. We will continue to conduct more detailed tests to clarify the ejection mechanism and improve ejection efficiency.

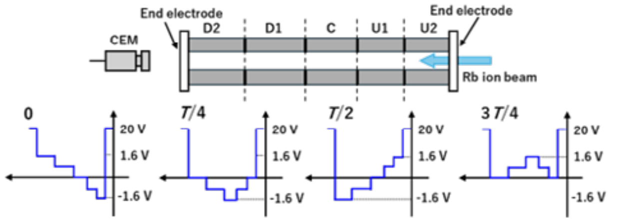

Fig. 1. Swing field by changing the DC potential in the RF ion trap. CEM is the ion detector. T represents the period of the swing field.

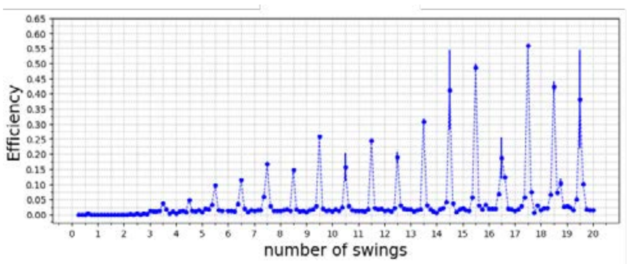

Fig. 2. Ejection efficiency when the number of swings is changed. The extraction efficiency was defined by the ratio of the number of detected ions after the swings to the number of ions injected to the RF trap (*i.e.*, the efficiency is defined by the beam intensity multiplied by the accumulation time) to obtain the detection efficiency, and the average values of three runs are shown, with the variance as the error bar.

References

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