Laser spectroscopy of triply charged thorium ions towards a nuclear clock

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The first-excited nuclear state of ^{229}Th (^{229m}Th) attracts attention for its extremely low energy. Its energy was measured to be 8.3 eV (corresponding to the wavelength of 149 nm) by internal conversion electron spectroscopy and γ-ray spectroscopies [1-4]. The nuclear transition between the ground state and the first-excited state of ^{229}Th thus offers unique opportunities for direct high-precision laser spectroscopy of an atomic nucleus. One of the applications is an optical nuclear clock: an atomic clock based on this nuclear transition [5].

The ion trap is an ideal platform for the nuclear clock because the quantum states of isolated ^{229}Th ions in a trap can be precisely controlled by laser cooling. We are aiming to trap triply charged ^{229}Th ions which possess electronic transitions suitable for laser cooling [6]. Figure 1 shows a schematic of our apparatus. The ^{229}Th^{3+} recoil ions emitted from the ^{233}U source are collisionally cooled with helium buffer gas and extracted as a low-energy ion beam by an RF-carpet [7]. The transported ^{229}Th^{3+} ions are trapped in a linear Paul trap and used for laser cooling experiments.

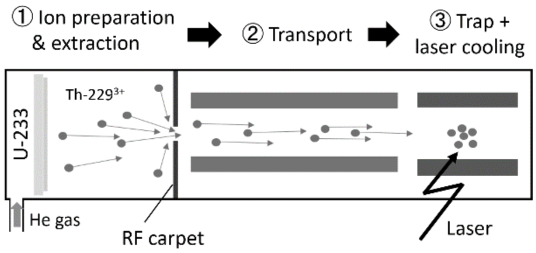

Fig. 1 Schematics of ^{229}Th^{3+} ion trap apparatus developed in this study.

We have been developing this apparatus by using ^{232}Th^{3+} ions instead of ^{229}Th^{3+} ions because ^{232}Th isotope is much easier to handle due to its large natural abundance and less radioactivity than ^{229}Th. We installed a ^{232}Th plate instead of the ^{233}U source. The ^{232}Th^{3+} ions are obtained by laser ablation. We will present latest results on trapping and laser spectroscopy of ^{232}Th^{3+} ions.

References

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