Development of an RF-carpet gas cell to obtain a low-energy thorium ion beam

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The first-excited isomeric state of ^{229}Th (^{229m}Th) attracts attention for its extremely low energy. Existence of ^{229m}Th was confirmed via observation of electrons emitted by internal conversion (IC) decays [1]. Laser spectroscopy of ^{229m}Th^{2+} was also demonstrated [2]. The energy of the ^{229m}Th was measured to be approximately 8 eV by IC electron spectroscopy [3] and γ-ray spectroscopies [4, 5, 6]. The nuclear transition between the ground and isomeric states of ^{229}Th thus offers unique opportunities for high-precision laser spectroscopy of an atomic nucleus. One of the promising applications is an optical nuclear clock: an atomic clock based on this nuclear transition [7]. 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 manipulated by lasers.

We are developing an RF-carpet gas cell to obtain a low-energy ^{229}Th ion beam which can be used as an ion source for ion trap experiment. The ^{229}Th recoil ions emitted from ^{233}U source are cooled by collisions with He buffer gas and extracted as a low-energy ion beam by an RF-carpet [8]. Since 2% of recoil ^{229}Th ions from ^{233}U are ^{229m}Th, laser spectroscopy of trapped ^{229m}Th ions could also be performed by attaching the ion trap to the gas cell developed in this study, which would provide more detailed knowledge of this unique nuclear state.

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