

An optical clock based on a highly charged ion

Highly charged ions (HCI) have long been proposed for the application in optical clocks due to their high sensitivity to fundamental physics and suppressed sensitivity to external field shifts [1]. However, their application as frequency references has long been impeded by the megakelvin temperatures at which HCI are typically produced and stored. In our lab, these obstacles have been overcome by first extracting HCI from a plasma and transferring them to a cryogenic linear Paul trap. There, a single HCI is sympathetically cooled using singly-charged Be^+ ions, enabling quantum logic spectroscopy with Hz-level resolution [2] and cooling of all motional modes to their ground state [3]. This paved the way for the first optical clock employing a HCI, here Ar^{13+} . The evaluation of the experimental setup yielded a systematic uncertainty of 2×10^{-17} , comparable to many other optical clocks. The leading systematic shift is time-dilation from excess micromotion, which will be remedied by a new trap. The frequency of the electric dipole-forbidden transition in Ar^{13+} was compared to the well-known octupole transition in $^{171}\text{Yb}^+$. The derived absolute frequency and isotope shift ($^{36}\text{Ar}^{13+}$ vs $^{40}\text{Ar}^{13+}$) are an improvement of eight and nine orders of magnitude respectively over the previous best result. For the first time, this has enabled to resolve the QED nuclear recoil in a many-electron system [3]. Further atomic parameters can be extracted from the measurements and are in excellent agreement with theoretical predictions. Transferring the applied techniques to other HCI systems is straight forward and we demonstrate this using Ca^{14+} . There we investigated the isotope shift of the transition frequency. These results will be used to test fundamental physics and search for new physics [4, 5].

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