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A highly charged ion based optical atomic clock

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Abstract

Optical atomic clocks are the most accurate devices ever built and are used as time standards as well as probes for fundamental physics. They are usually based on transitions in neutral or singly charged atoms. The large class of highly charged ions (HCI) remained so far unexplored. This is despite favourable properties of HCI, like a small sensitivity to external fields and a high sensitivity to physics beyond the Standard Model. Over the last decade several key hinderances were eliminated by sympathetic cooling of HCI and interrogation using quantum logic spectroscopy. Here, an optical clock based on the dipole-forbidden, optical transition in Ar13+ is presented. A comprehensive analysis of the systematic shifts shows a systematic uncertainty of 2*10^-17 with a clear path to below 10^-18. Clock comparison to the well-known octupole transition in singly charged Yb yielded an absolute frequency eight orders of magnitude more accurate than any previous value. The measured isotope shift (40Ar – 36Ar) is compared to high-precision calculations and reveals for the first time the quantum electrodynamic nuclear recoil in a many-electron atom. The applied techniques are universal and open high precision spectroscopy for a large variety of HCI.