Highly Charged Ion Clocks for the Extreme Ultraviolet Region, and Beyond

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Optical clocks use the frequencies of forbidden transitions as extremely stable pacemakers. At higher photon energies, photoionization couples the excited states to the continuum, broadening the lines and impeding close-cycle interrogation schemes. Highly charged ions (HCI) sustain a great variety of very narrow forbidden transitions even at X-ray energies, and could thus serve for referencing atomic clocks that can potentially become more accurate than presently possible [1]. Both the high frequencies of those transitions in the extreme-ultraviolet region and the much-reduced polarizability of HCI should facilitate achieving that aim. Moreover, the strong nuclear overlap of the electronic wave functions in HCI and the large number of possible clock transition in the extended photon energy range enhances the sensitivity of King-plot-based searches to New Physics [2,3]. Our recent demonstration of an optical clock based on HCI [4] paves the way for bringing frequency metrology beyond the optical range, for which we are preparing an experiment combining an extreme-ultraviolet frequency comb based on high-harmonic-generation [5] with a superconducting radio-frequency trap [6].

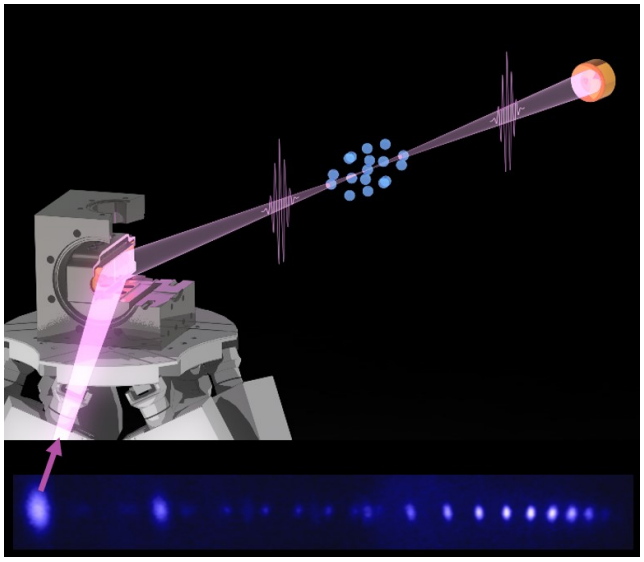

Figure 1: A 100 MHz XUV frequency comb emits in each high harmonic a comb of lines. These are focused on a sympathetically cooled highly charged ion embedded in a laser-cooled Coulomb crystal for the study of forbidden XUV transitions

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