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Towards XUV Frequency Comb Spectroscopy of the 1s-2s Transition in He+

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Bound-state quantum electrodynamics (QED) accurately describes the energy levels of hydrogen-like atoms and ions. High-precision laser spectroscopy experiments provide one of the best tests of the theory. The frequency of the narrow 1s-2s transition of atomic hydrogen has been measured with a relative uncertainty of less than 10^{-14}. By combining two spectroscopic measurements of a hydrogen-like system the Rydberg constant and the nuclear charge radius can be determined. The comparison of the physical constants obtained from different combinations of measurements serves as a consistency check for the theory [1]. It is interesting to measure different hydrogen-like systems since they have a higher sensitivity to different contributions of the theory. The measurement of the Lamb shift in muonic hydrogen, for instance, has enhanced sensitivity to the proton radius and gave rise to the proton radius puzzle [2]. Another interesting spectroscopic target is the hydrogen-like He^+ ion. Interesting higher-order QED corrections scale with large exponents of the nuclear charge, making measurements in He^+ much more sensitive to these corrections compared to hydrogen. In this poster, we describe our progress towards precision spectroscopy of the 1s-2s two-photon transition in He^+ [3]. Ideal conditions for high-precision measurements can be achieved by holding a small number of He^+ ions nearly motionless in the field-free environment of a Paul trap. There, they are sympathetically cooled by co-trapped Be^+ ions. The 1s-2s transition can be directly excited by an extreme-ultraviolet frequency comb at 60.8 nm, which is generated by a high-power infrared frequency comb using high-harmonic generation. After successful excitation to the 2s state, a significant fraction of the He^+ ions will be further ionized to He^{2+} and remain in the Paul trap. Sensitive mass spectrometry using secular excitation will reveal the number of trapped He^{2+} ions and will serve as a single-event sensitive spectroscopy signal.

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