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Ramsey-comb spectroscopy at short wavelengths for fundamental tests[1]

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Spectroscopy of atoms and molecules has become ever more advanced and accurate, especially after the invention of the frequency comb laser. Precision spectroscopy can be used to e.g. test fundamental physics such as bound-state QED, or for determining fundamental constants. We pursue two targets for those purposes, 1S-2S spectroscopy of singly-ionized helium, and a determination of the ionization potential of molecular hydrogen, which require light sources at deep-ultraviolet or shorter wavelengths for excitation from the ground state. Despite demonstrations of e.g. extreme ultraviolet frequency comb generation by nonlinear upconversion, precision spectroscopy remains challenging at such wavelengths. We developed a method, called Ramsey-comb spectroscopy (RCS), that largely overcomes those challenges. It is based on direct excitation with only two amplified and upconverted ultrafast frequency comb laser pulses to generate a form of Ramsey fringes. The frequency comb laser provides the required phase and timing control of the light pulses, while the short pulses enable amplification to high peak power for efficient upconversion of the optical frequencies. By comparing Ramsey signals recorded at two or more inter-pulse delays (spaced at multiples of the comb repetition time), the phase evolution of signal is recorded as a function of time, from which an accurate transition frequency is determined. In the talk I will discuss how this works, and illustrate it with our latest progress on RCS of the X-EF transition in para-hydrogen at 202 nm, and with our recent demonstration of RCS of xenon at 110 nm where we reached the highest spectroscopic accuracy achieved so far with light produced by high-harmonic generation. This experiment was done in preparation of exciting the 1S-2S two-photon (using 32 nm and 790 nm) transition in trapped, singly-ionized helium, which will be discussed too

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