

# An XUV frequency comb using HHG for metrology of Highly Charged Ions

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Forbidden optical transitions in highly charged ions (HCI) are the most sensitive systems for probing the variation of the fine structure constant  $\alpha$  [1]. Moreover, they have been proposed as novel frequency standards due to their low polarizability and insensitivity to black body radiation [2]. HCI are typically produced in an electron beam ion trap (EBIT) with MK temperatures, which restricts the achievable accuracy in frequency determinations to ppm levels [3]. However, recent developments at our institute have overcome these limitations by extracting, slowing and subsequent re trapping the HCI in a Paul Trap, where they are sympathetically cooled by a  $\text{Be}^+$  crystal [4]. This has enabled the first high precision laser spectroscopy of  $\text{Ar}^{13+}$  using quantum logic spectroscopy, gaining many orders of magnitude in precision compared to all previous experimental measurements [5].

The experiment presented here aims at high precision spectroscopy in the extreme ultraviolet (XUV), where many transitions, from dipole-allowed (E1) to highly forbidden, take place. Femtosecond pulses from a 100 MHz phase stabilized infrared (IR) frequency comb around 1035 nm are amplified and fed into an enhancement cavity inside the UHV vacuum chamber [6]. In the tight focus (waist size  $\approx 15 \mu\text{m}$ ) of the cavity, where intensities of up to  $2 \cdot 10^{14} \text{W/cm}^2$  are reached, the IR light interacts with a noble gas inserted from a nozzle with a very high backing pressure. High harmonics are generated collinearly with the cavity beam and are spatially separated using a shallow diffraction grating etched in one of the cavity mirrors [7]. In this way, we can now generate XUV radiation with wavelengths ranging from 35 to 150 nm. Since each harmonic is a coherent copy of the infrared frequency comb [8], any of the comb teeth in any of the harmonics can be used to resonantly drive an electronic transition in the highly charged ion. Using this technique of direct frequency comb spectroscopy, absolute transition energies can be determined with an unprecedented precision in the XUV [9]. The measured output power of 10  $\mu\text{W}$  per harmonic is already feasible for fluorescent detection of dipole-allowed transitions in HCI. The latest results and current work on further increasing and stabilizing the output power will be presented, as well as its future prospects in ultra-high precision spectroscopy of cooled and trapped HCI.

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