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Cold Highly Charged Ions for Fundamental Studies in the Vacuum Ultraviolet[1]

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Sympathetic cooling of highly charged ions (HCI) [1] in combination with quantum logic spectroscopy [2] has recently allowed us improving the determination of optical frequencies in HCI by eight orders of magnitude [3]. This method will soon enable the study of transitions that are extremely sensitive to a possible variation of the fine-structure constant α, with Pr^{9+} as a very interesting case [4]. Moreover, HCI also possess extremely forbidden photon transitions of high multipolarity up to the x-ray region, while being protected from photoionization by the high binding energies of their outer electrons. Their very low polarizabilty strongly suppress systematic shifts such as those due to laser power and blackbody radiation.
We are currently building an experiment [5] in order to extend the range of frequency metrology into the vacuum-ultraviolet (VUV) region with HCI using a VUV frequency comb for excitation and spectroscopy, and a superconducting radio-frequency ion trap for storage. This setup should allow us to study bound-bound transitions of interest for QED and isotopic nuclear size studies at much higher photon energies than in atoms. Such investigations have been recently proposed, e. g., for setting upper bounds for the strength of interactions beyond those presently known, and other fundamental studies [6]. The possibility of frequency metrology in the VUV region will also open new opportunities for other scientific fields.

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