Highly charged ions for probing the time variation of the fine-structure constant

PD Dr. José R. Crespo López-Urrutia

Max-Planck-Institut für Kernphysik, Heidelberg

Sympathetically cooled highly charged ions (HCI) can improve the operation of optical clocks in order to set new limits on possible variations of the fine-structure constant in space or time. A variation of this fundamental constant has been claimed based on astrophysical observations, yet its magnitude is still too small for laboratory consistency checks. The currently best benchmarks are based on comparing frequencies of different optical clocks with a relative accuracy of 10-17 per year. Forbidden optical transitions in HCI [1] offer major advantages as optical frequency references. Compared with atoms or singly charged ions, their deeply bound optically active electron shows greatly reduced systematic shifts by external perturbations, such as those due to interrogation by lasers or blackbody radiation. At the same time, in the proposed HCI-optical clocks relativistic effects enhance the sensitivity to a variation of the fine-structure constant. Furthermore, we have investigated in certain HCI near-degeneracies of electronic states that are very amenable to frequency metrology and particularly sensitive to the effect of interest [2]. We have developed a cryogenic radiofrequency trap, CryPTEx (Cryogenic Paul Trap Experiment) [3], for preparing sympathetically cooled Ir17+ and Ar13+ ions for these studies [4]. Presently we are searching for the lasing transitions of interest. The current status of the experiment will be presented.

[1] V. Mäckel, et al., Laser spectroscopy on forbidden transitions in trapped highly charged Ar13 + ions, Phys. Rev. Lett. 107 (2011) 143002
[2] A. Windberger, et al., Identification of the Predicted 5s-4f Level Crossing Optical Lines with Applications to Metrology and Searches for the Variation of Fundamental Constants, Phys. Rev. Lett. 114 (2015) 150801,
[3] M. Schwarz et al., Rev. Sci. Instrum. 83 (2012) 083115
[4] L. Schmöger, et al., Coulomb crystallization of highly charged ions,

Science 347 (2015) 1233