A 43: Precision spectroscopy of atoms and ions VI (with Q)

Time: Friday 11:00–12:30 Location: B 305

Invited Talk A 43.1 Fri 11:00 B 305

Accurate, stable, transportable: lattice clocks at PTB — •Christian Lisdat, Stephan Falke, Nathan Lemke, Thomas Middelmann, Stefan Vogt, Sebastian Häfner, and Uwe Sterr — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

After an introduction to the ideas of optical clocks in general and lattice clocks in particular we will present recent improvements on the strontium lattice clocks of PTB. The typical benchmarks of clocks are their accuracy and stability – where substantial improvements have been achieved by the highly accurate evaluation of the dominating source of uncertainty of Sr lattice clocks [1] and the application of an extremely coherent laser [2] for the interrogation of the atomic clock transition in strontium. Now, PTB's laboratory lattice clock is expected to achieve its uncertainty of 4×10^{-17} after an averaging time of less than 200 s. We will use our clock for measurements aiming at posing improved limits on the time variation of fundamental constants. So far these formidable measurement devices are only available in few laboratories in the world. By building a transportable lattice clock we want to develop an instrument for frequency comparisons, tests of e.g. the gravitational redshift or applications like relativistic geodesy with high temporal resolution.

[1] T. Middelmann *et al.*: High accuracy correction of blackbody radiation shift in an optical lattice clock; Phys. Rev. Lett in press (2012).
[2] T. Kessler *et al.*: A sub-40 mHz linewidth laser based on a silicon single-crystal optical cavity; Nature Photonics **6**, 687–692 (2012).

A 43.2 Fri 11:30 B 305

Development of Scalable Ion Traps for Optical Clocks — •Tobias Burgermeister[1], Karsten Pyka[1], Jonas Keller[1], Heather L. Partner[1], Kestutis Kurselis[2], Roman Kiyan[2], Carsten Reinhardt[2], Daniel Hagedorn[1], Rudolf Meess[1], and Tanja E. Mehlstäubler[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [2]Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

Our work focuses on the realization of an optical clock with a fractional frequency inaccuracy as low as 10^{-18} and improved short-term stability. It is based on multiple $^{115}In^{+}$ ions which are sympathetically cooled by $^{172}Yb^{+}$ ions.

Within a new European joint research project we develop chip-based linear ion traps for quantum metrology. Using an operating prototype trap [1,2] we characterize excess micromotion and demonstrate sympathetic cooling of In^{+}/Yb^{+}-crystals. We show that our trap design provides a highly controllable environment for precision spectroscopy and experiments with ion Coulomb crystals.

An advanced next generation ion trap, will be based on gold coated aluminum nitride wafers, which are laser machined at LZH and PTB. For this new trap design we perform theoretical and experimental thermal studies at MIKES (Finland) and CMI (Czech Republic), which will characterize the influence of trap heating on the clock measurement.

[1] Pyka *et al.*, *arXiv*:1206.5111v1 (2012)
[2] Herschbach *et al.*, *Appl. Phys. B* **107**, 891 (2012)

A 43.3 Fri 11:45 B 305

Optical Clock with a Generalized Ramsey Scheme — •Nils Huntemann, Burghard Lipphard, Christian Tamm, and Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

We experimentally investigate a recently proposed optical excitation scheme [1] that is a generalization of Ramsey's method of separated oscillatory fields. The excitation pulse sequence is tailored to produce a resonance signal that is immune to the light shift and other shifts of the transition frequency that are correlated with the interaction of the atomic system with the probe light field. We investigate the scheme using a single trapped $^{171}Yb^{+}$ ion and perform spectroscopy on the highly forbidden $^{2}S_{1/2} - {}^{2}F_{7/2}$ electric-octupole transition that exhibits a strong light shift. This transition serves as a reference in an optical clock, whose accuracy critically depends on the degree of light shift suppression [2]. Our experiments on the new excitation method clearly show a suppression of the light shift by four orders of magnitude and an immunity against its fluctuations [3]. The superior performance of the new technique is demonstrated in a frequency ratio measurement with another optical clock.

[1] V. I. Yudin et al., PRA **82**, 011804 (2010)
[2] N. Huntemann et al., PRL **108**, 090801 (2012)
[3] N. Huntemann et al., PRL **109**, 213002 (2012)

A 43.4 Fri 12:00 B 305

Optical spectroscopy on Ir^{17+} for the determination of transitions extremly sensitive on a variation of the fine-structure constant — •Alexander Windberger[1], Hendrik Bekker[1], Christian Beilmann[2], Renee Klawitter[3], Piet O. Schmidt[4,5], Oscar O. Versolato[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik — [2]Karlsruher Institut für Technologie — [3]Tri University Meson Facility — [4]Physikalisch-Technische Bundesanstalt — [5]Leibniz Universität Hannover

The fine-structure constant α is closely related to fundamental physics. Thus, a temporal variation would point towards physics beyond the Standard Model. Evidence for a variation $\dot{\alpha}/\alpha \approx 10^{-19}$/year has been claimed by [1] based on astronomical observations. In order to test this claim in a laboratory experiment, two accurate ion clocks can be compared to search for a drift in $\dot{\alpha}$-sensitive clock transitions. Moving from singly charged to highly charged ions can enhance, both, the clock accuracy, and the $\dot{\alpha}$-sensitivity to meet the requirements. Particularly, the highest sensitivity for $\dot{\alpha}$ ever predicted for a stable atomic system is found in Ir^{17+} by [2]. To determine the wavelength of the predicted transitions accurately, optical spectroscopy on Ir^{17+} is performed inside the Heidelberg electron beam ion trap (EBIT) at a ppm accuracy level. This will allow for future precision experiments, where Ir^{17+} will be transfered from an EBIT into the Cryogenic Paul Trap Experiment (CryPTEx).

[1] J. K. Webb *et al.*, *Phys. Rev. Lett.* **107**, 191101 (2011).
[2]J. C. Berengut *et al.*, *Phys. Rev. Lett.* **106**, 210802 (2011).

A 43.5 Fri 12:15 B 305

Towards Laser Cooling of Negative Ions — •Elena Jordan, Sophia Haude, Anke Heilmann, and Alban Kellerbauer — MPI für Kernphysik, Heidelberg

Ultra-cold negative ions could be used in a wide field of applications. We intend to demonstrate the first laser cooling of atomic anions. In order to identify suitable laser cooling transitions, we study negative ions by high-resolution laser spectroscopy. Previously the transition frequencies and transition cross-sections of various Os^{-} isotopes were determined [1]. The isotope shift and the hyperfine structure (where applicable) were resolved [2,3], and the Zeeman splitting in a magnetic field was measured [4]. These measurements have shown that laser cooling of Os^{-} is possible in principle, but is hampered by a low cooling transition rate. Presently we are pursuing high-resolution spectroscopy on La^{-}, which has been identified as another potential candidate for anion laser cooling [5].

[1] U. Warring et al., Phys. Rev. Lett. 102 (2008) 043001.
[2] A. Fischer et al., Phys. Rev. Lett. 104 (2010) 073004.
[3] A. Kellerbauer et al., Phys. Rev. A 84 (2011) 062510.
[4] A. Kellerbauer et al., submitted to Phys. Rev. Lett.
[5] S. M. O'Malley & D. R. Beck, Phys. Rev. A 81 (2010) 032503.