A 10: Precision Measurements and Metrology III (with Q)

Time: Monday 17:00–18:15 Location: a310

A 10.1 Mon 17:00 a310

Comparison of a ^{171}Yb^{+} single ion clock and a ^{87}Sr lattice clock with 2×10^{-17} uncertainty — •Nils Huntemann, Sören Dörscher, Ali Al-Masoudi, Sebastian Häfner, Christian Grebing, Burghard Lipphardt, Christian Tamm, Uwe Sterr, Christian Lisdat, and Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

We report on a comparison of two optical clocks based on the ^{2}S$_{1/2}$ $\leftrightarrow$ ^{2}F$_{7/2}$ transition of a single ^{171}Yb^{+} ion stored in a radio-frequency Paul trap and on the ^{1}S$_{0}$ $\leftrightarrow$ ^{3}P$_{0}$ transition of thousands of ^{87}Sr atoms confined in an optical lattice. While the lattice clock achieves frequency instabilities smaller than $2 \times 10^{-16}/\sqrt{\tau/\mathrm{s}}$, a systematic uncertainty of 3×10^{-18} has been reported for the ion clock. From more than 80 h of acquired data, we determine the frequency ratio of the two clocks with a fractional uncertainty of 2.4×10^{-17}. This is the smallest uncertainty achieved between clocks of different types to date and enables consistency tests in other laboratories developing the same combination of optical clocks. Moreover, the experiment is well suited to search for temporal variations of the fine structure constant α due to the large sensitivity of the E3 transition frequency. Data from this measurement and a similar one performed 2.5 years earlier constrain a potential linear drift $\dot{\alpha}/\alpha$ to below 1×10^{-17}/yr.

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A 10.2 Mon 17:15 a310

The magnesium optical lattice clock at the IQ — •Dominika Fim, Steffen Rühmann, Klaus Zipfel, Nandan Jha, Steffen Sauer, André Kulosa, Wolfgang Ertmer, and Ernst M. Rasel — Leibniz Universität Hannover, Institut für Quantenoptik, Hannover

Optical lattice clocks based on fermionic strontium already reached uncertainties in the low 10^{-18} regime and are studied among others by JILA and NIST. In Hannover at the IQ, we operate an optical lattice clock based on bosonic magnesium atoms. Magnesium has a relatively simple electronic structure and hence allows for the implementation of very precise atomic structure models.

Recent measurements of the magic wavelength, which we could determine to 468.48(21) nm, and the 2$^{\text{nd}}$ order Zeeman shift were limited due to tunneling effects which results in a 10 kHz broad clock transition linewidth. In this presentation we will give a status update, where we will report on the optical lattice with a reduced tunneling rate and in this context more accurate measurements on the magic wavelength and the 2$^{\text{nd}}$ order Zeeman shift. We also prepare the optical lattice clock for a frequency measurement and will give the first estimations for the frequency accuracy for our apparatus.

A 10.3 Mon 17:30 a310

A strontium-based atomic breadboard for the Space Optical Clock mission on the ISS — •Stefano Origlia[1], Stephan Schiller[1], Lyndsie Smith[2], Yeshpal Singh[2], Dariusz Świerad[2], Sruthi Viswam[2], Wei He[2], Joshua Huges[2], Kai Bongs[2], Uwe Sterr[3], Christian Lisdat[3], Stefan Vogt[3], and the SOC2 team[1] — [1]HHU, Düsseldorf, Germany — [2]University of Birmingham, UK — [3]PTB, Braunschweig, Germany

The rapid improvement in the performance of optical clocks are opening the door to new technological and scientific applications. Ultra-precise optical clocks in space will allow many experiments, as in the field of fundamental physics (Einstein's gravitational time dilation), time and frequency metrology (comparison between ground clocks using a master clock in space), geophysics (space-assisted relativistic geodesy) and astronomy (local oscillators for radio ranging and interferometry in space). The ESA candidate mission Space Optical Clocks project aims at operating an optical lattice clock on the ISS in approximately 2022.

Within an EU-FP7-funded project, a compact and robust strontium optical lattice clock demonstrator is being developed with a goal instability of $1 \times 10^{-15}\tau^{-1/2}$ and a goal inaccuracy of 5×10^{-17}. For the design of the clock, techniques and approaches suitable for later space application are used, such as modular design, diode lasers, low power consumption, and compact dimensions. The atomic part is operative at the point where atoms are reliably trapped into the optical lattice. The latest results and future perspectives will be presented.

A 10.4 Mon 17:45 a310

Squeezed vacuum for sub-shot-noise frequency metrology — •Ilka Kruse[1], Karsten Lange[1], Jan Peise[1], Bernd Lücke[1], Luca Pezzè[2], Jan Arlt[3], Wolfgang Ertmer[1], Luis Santos[4], Augusto Smerzi[2], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]QSTAR, INO-CNR and LENS, Firenze, Italy — [3]Institut for Fysik og Astronomi, Aarhus Universitet, Denmark — [4]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

All interferometers with classical input states are limited by the shot-noise limit due to the finite particle number. In particular, this effect imposes a limitation for the stability of state-of-the-art atomic microwave clocks. In optics, squeezed vacuum is widely used to overcome this limitation and to operate interferometers beyond the shot-noise limit. Here we create a squeezed vacuum state in an ultracold atomic ensemble by spin-changing collisions. We employ this entangled state to demonstrate a sub-shot-noise frequency measurement in ^{87}Rb. Our frequency measurement shows a minimal fractional instability of 6.1×10^{-10} and a sensitivity of 1.5 dB below shot-noise.

A 10.5 Mon 18:00 a310

Decoherence related limitation of light shift immune Ramsey schemes — •Sergey Kuznetsov[1,2], Nils Huntemann[1], Christian Sanner[1], Burghard Lipphardt[1], Christian Tamm[1], and Ekkehard Peik[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — [2]Institute of Laser Physics SB RAS, Novosibirsk 630090, Russia

Over the last years generalizations of Ramsey's method of separated oscillatory fields were proposed that provide immunity to probe-induced frequency shifts [1-3]. They are of particular importance for optical clocks, based on strongly forbidden transitions, where the probe light field induces a significant light shift via non-resonant coupling to higher lying levels. We apply such a technique for our optical clock based on the ^{2}S$_{1/2}$ $\leftrightarrow$ ^{2}F$_{7/2}$ transition of a single ^{171}Yb^{+} ion stored in a radio-frequency Paul trap [4]. Heating of the ion's motion during the probe period, however, degrades the cancellation of the light shift. We present a theoretical investigation of the effect and compare it with experimental data. We furthermore present a way to compensate for the effect of motional heating.

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[1] V.I. Yudin, *et al.*, PRA **82**, 011804 (2010).
[2] R. Hobson, *et al.*, arXiv:1510.08144.
[3] T. Zanon-Willette, E. de Clercq, E. Arimondo arXiv:1511.04847.
[4] N. Huntemann *et al.*, PRL **109**, 213002 (2012).