Q 41: Precision Measurement and Metrology 1

Time: Wednesday 16:30–18:00 Location: HÜL 386

Q 41.1 Wed 16:30 HÜL 386

Frequency standard based on the octupole transition in ^{171}Yb$^+$ — •Nils Huntemann, Maxim Okhapkin, Burghard Lipphard, Stefan Weyers, Christian Tamm, and Ekkehard Peik — Fachbereich Zeit und Frequenz, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

We present our results on the development of a new optical frequency standard based on the electric octupole (E3) transition ^{2}S$_{1/2}$(F = 0) → ^{2}F$_{7/2}$(F = 3) of a single trapped laser-cooled ^{171}Yb$^+$ ion at 467 nm.

In comparison with a previously realized optical frequency standard in ^{171}Yb$^+$ [Tamm *et al.*, Phys. Rev. A **80** 043403 (2009)] this E3 transition benefits from smaller systematic level shifts due to external fields and its negligible natural linewidth. Another important aspect of the new standard is its strong dependence on variations of the fine structure constant α.

A recently built probe laser system [Sherstov *et al.*, Phys. Rev. A **81** 021805(R) (2010)] and the use of a new efficient repump scheme allows to observe Fourier transform-limited linewidths below 7 Hz and a resonant excitation probability of more than 90 %.

We lock the probe laser frequency to the resonance signal of the E3 transition and use a real-time extrapolation scheme to eliminate the huge light shift induced by the probe field. The unperturbed transition frequency was measured by a comparison to a caesium fountain clock using a frequency comb generator. The resulting uncertainty was mainly limited by the systematic uncertainty of the fountain clock.

Q 41.2 Wed 16:45 HÜL 386

Optical Lattice Clock with ^{87}Sr — •Stephan Falke, Thomas Middelmann, Fritz Riehle, Uwe Sterr, and Christian Lisdat — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

We present an absolute frequency measurement of the $5s^2\ {}^1S_0$ – $5s5p\ {}^3P_0$ transition of ^{87}Sr against the Cs fountain clock CsF1 at PTB. An ultrastable laser with a linewidth of about 1 Hz interrogates an ensemble of ultracold fermionic strontium atoms that are held in an optical lattice. The lattice laser is set to the magic wavelength at 813 nm. The trapping allows for Doppler-free spectroscopy and interrogation times of 90 ms. The interrogating laser is locked to the atoms by measuring the transition probability for the two extreme Zeeman components that show a Fourier linewidth of 10 Hz.

The systematics of the Sr system itself has been investigated using an alternating stabilization technique. It is found to be better than, both, the systematic and the statistical uncertainty of the Cs clock.

With the alternating stabilization scheme, we measured the magic wavelength for the optical lattice. This frequency is determind to the level of a few MHz.

By comparing the transition frequency for different densities we looked for the effect of collisions (density shift). Such shifts can at least be reduced to 3×10^{-17} for our experimental configuration.

The work is supported by the Centre for Quantum Engineering and Space-Time Research (QUEST), ESA, DLR, and the ERA-NET Plus Programme.

Q 41.3 Wed 17:00 HÜL 386

Towards an optical frequency standard based on cold neutral magnesium atoms in an optical lattice — •André P. Kulosa, André Pape, Temmo W. Wübbena, Jan Friebe, Matthias Riedmann, Hrishikesh Kelkar, Steffen Rühmann, Dominika Fim, Klaus H. Zipfel, Wolfgang Ertmer, and Ernst-M. Rasel — Leibniz Universität Hannover, Institut für Quantenoptik, Hannover

Optical clocks have exceeded today's best atomic microwave clocks in accuracy and stability. The alkaline earth atoms are promising candidates for possible future optical frequency standards. Magnesium shows an attractive benefit with its low sensitivity to black body radiation shift at room temperature, which is a limiting contribution to today's best optical clocks.

Our current magnesium frequency standard is based on cold free-falling atoms interrogated on the narrow intercombination line ^{1}S$_0$ - ^{3}P$_1$ using a Ramsey-Bordé-interferometer geometry.

We trap the bosonic isotope ^{24}Mg in an optical dipole trap at 1064 nm during a MOT-cooling stage in the triplet manifold. We are able to accumulate 10^5 atoms at a temperature of 100 μK in the dipole trap using a continuous loading scheme. The atoms will be transferred to an optical lattice at the magic wavelength which is predicted to be 463 nm. The power in the lattice is enhanced using a build-up cavity.

Q 41.4 Wed 17:15 HÜL 386

Precision measurement of the 1S-2S transition in atomic hydrogen — •Christian G. Parthey[1], Arthur Matveev[1], Janis Alnis[1], Axel Beyer[1], Nikolai Kolachevsky[1], Randolf Pohl[1], Thomas Udem[1], and Theodor W. Hänsch[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching — [2]Ludwig-Maximilians-Universität, 80799 München

Precision spectroscopy of the 1S-2S transition in atomic hydrogen has been used to test quantum electro dynamics (QED), determine the Rydberg constant and the proton charge radius. It can also be used to set limits on possible Lorentz-boost invariance violations. Here we report on a new measurement of the 1S-2S transition pushing the uncertainty to the 10^{-15} level.

Q 41.5 Wed 17:30 HÜL 386

Using $(\Delta F = 1, \Delta m_F = \pm 1)$ transitions as a diagnostic tool for atomic fountain clocks — •Nils Nemitz, Vladislav Gerginov, Stefan Weyers, and Robert Wynands — Physikalisch-Technische Bundesanstalt, Braunschweig

Atomic caesium fountain clocks provide the most accurate realization of the SI second by making use of the $|F = 3, m_F = 0\rangle$ to $|F = 4, m_F = 0\rangle$ hyperfine transition.

A leading contribution to their uncertainty budget arises from the effects of phase gradients in the microwave cavity. A better understanding of the atomic distribution during each of the two cavity passages would help in putting stricter limits on this uncertainty.

We have recently investigated a new method of obtaining information on the center-of-mass position during either cavity passage for the fraction of atoms contributing to the actual frequency measurement. It is based on a position-dependent change of the $\Delta m = \pm 1$ spectra when the normally vertical quantization field is tilted slightly. This type of spectra is normally not investigated in fountain clocks.

We will present experimental evidence and an analytical model that promises an achievable accuracy of the measured center-of-mass position of better than 0.3 mm.

Q 41.6 Wed 17:45 HÜL 386

Laser spectroscopy of trapped thorium ions — •Óscar-Andrey Herrera-Sancho[1], Maxim Okhapkin[1], Kai Zimmermann[1], Alexey Taichenachev[2], Valeriy Yudin[2], Christian Tamm[1], and Ekkehard Peik[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — [2]Institute of Laser Physics, Siberian Branch of RAS, Novosibirsk 630090, Russia

In our experiment more than 10^5 ^{232}Th$^+$ ions are stored in a linear Paul trap after creation by laser ablation from thorium metal. Single-frequency laser excitation in the complex spectrum of Th$^+$ poses the problem that spontaneous decay populates a number of metastable levels that are decoupled from the laser. Helium and Argon buffer gas are used for collisional cooling and quenching of those levels. We observe laser excitation of the strong resonance line at 401.9 nm with an extended-cavity diode laser and laser excitation of several other transitions around 400 nm and 270 nm with harmonics of a pico-second Ti:Sa laser. In a theoretical analysis we approximate the dense electronic level structure of Th$^+$ ions by just four levels: the ground state and an excited state are coupled by the primary laser, one metastable state is depopulated by a repumper laser and one level by collisions only. The model agrees with experimental results for the fluorescence rate as a function of the laser intensities and can be used to deduce populations and quenching rates. First investigations on two-photon excitation of the Th$^+$ electron shell to the energy range 7.8 eV of the nuclear transition of ^{229}Th are in progress.