A 4: Präzisionsmessungen und Metrologie 1

Time: Monday 10:30–12:30 Location: V47.02

A 4.1 Mon 10:30 V47.02

Detecting the single photon recoil of a single ion — •Cornelius Hempel[1,2], Benjamin P. Lanyon[1,2], René Gerritsma[1,3], Petar Jurcevic[1,2], Florian Zähringer[1,2], Rainer Blatt[1,2], and Christian F. Roos[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Technikerstr. 21a, 6020 Innsbruck, Austria — [2]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria — [3]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

I will report on our current work to measure the recoil due to a single photon scattering from a single ion. For this experiment two ions are loaded into a linear ion trap: one well characterized 'measurement' ion and one, possibly unknown, 'spectroscopy ion' on which the photon scattering event is to be detected. The photon recoil energy excites the common vibrational mode shared by both ions. In order to detect this extremely small vibration, we make use of a very sensitive highly non-classical motional state. Our technique could have interesting applications in performing spectroscopy of atoms or molecules at the single photon / single atom level.

A 4.2 Mon 10:45 V47.02

First gravity measurements using the mobile atom interferometer GAIN — •Christian Freier, Malte Schmidt, Alexander Senger, Matthias Hauth, Vladimir Schkolnik, and Achim Peters — Humboldt-Universität zu Berlin, Institut für Physik, AG Optische Metrologie, Newtonstr. 15, 12489 Berlin

GAIN (Gravimetric Atom Interferometer) is a mobile gravimeter, based on interfering ensembles of laser cooled ^{87}Rb atoms in an atomic fountain configuration. After introducing the working principle of the interferometer, we present the results of the latest laboratory gravity measurement and progress made in controlling systematic effects.

The high-precision interferometer has reached a sensitivity of $2 \times 10^{-8}\mathrm{g}/\sqrt{\mathrm{Hz}}$ in its first measurement and is designed for a target accuracy of a few parts in 10^{10}g. Finally, we report on the next steps towards a mobile gravimeter for field use.

A 4.3 Mon 11:00 V47.02

Detection and manipulation of nuclear spins coupled weakly to Nitrogen-Vacancy centers — •Jan Honert[1], Helmut Fedder[1], Nan Zhao[1], Michael Klas[1], Junichi Isoya[2], and Jörg Wrachtrup[1] — [1]Universität Stuttgart, 70550 Stuttgart, Germany — [2]University of Tsukuba, Tsukuba, Japan

The ability to investigate weakly coupled nuclear spins via electron spin ancillae offers great potential for novel quantum sensing applications. Nitrogen-Vacancy centers in diamond with long spin coherence times (several ms) are promising solid state systems for quantum information processing and detection at room temperature.

In high magnetic fields single shot readout schemes promise sensing below the Heisenberg limit. Here, we present recent results of nuclear spins coupled weakly to Nitrogen-Vacancy centers in low magnetic fields using dynamical decoupling techniques and isotopically enriched diamonds. Details on detection schemes and robust manipulation of ^{13}C spins are discussed.

A 4.4 Mon 11:15 V47.02

Moving optical lattice for long range transport embedded in an optical clock — •Thomas Middelmann, Stephan Falke, Uwe Sterr, and Christian Lisdat — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Optical clocks have surpassed cesium microwave clocks in stability and systematic uncertainty. A major concern for optical clocks is the frequency shift due to ambient thermal radiation. It is currently limiting the systematic uncertainty of Sr optical lattice clocks to $1 \cdot 10^{-16}$ [1]. This blackbody shift can be described to high accuracy as a dc Stark shift from the rms electric field of the ambient blackbody radiation. Thus a dc Stark shift measurement allows a determination of the atomic response to a thermal radiation field. For this measurement ultracold Sr atoms need to be interrogated in the field of a precision capacitor [2]. Therefore a transport of ultracold atoms between the optical access region (MOT, detection) and the dc field (interrogation) is required in each clock cycle. Due to these spatial constrains and optical lattice requirements, we move the optical lattice by moving all its optics. We transport the atoms for 5 cm within 240 ms, with negligible heating, less than 4 % atom loss (back and forth), and maintain a clock stability of better than $3 \cdot 10^{-15}\ \mathrm{s}^{-1/2}$.

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

[1] Falke *et al.* Metrologia **48**, 399 (2011).

[2] Middelmann *et al.* IEEE Trans. Instrum. Meas. **60**, 2550 (2011).

A 4.5 Mon 11:30 V47.02

Interrogation laser with 5×10^{-16} instability for a magnesium optical lattice clock — •Andre Pape, Steffen Rühmann, Temmo Wübbena, André Kulosa, Hrishikesh Kelkar, Dominika Fim, Klaus Zipfel, Wolfgang Ertmer, and Ernst M. Rasel — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

Optical clocks revolutionized the field of time and frequency metrology and are outperforming today's best microwave clocks. Magnesium (Mg) is an attractive candidate for a neutral atom optical clock, due to its low sensitivity to blackbody radiation. For interrogation of the narrow atomic transitions in optical clocks, lasers with typically subhertz linewidths are essential. We present an ultrastable laser system with 5×10^{-16} instability for the future spectroscopy of the narrow $^1\mathrm{S}_0 \rightarrow {}^3\mathrm{P}_0$ clock transition at 458 nm on an ensemble of ^{24}Mg atoms confined to an optical lattice at the magic wavelength. The laser system is based on a diode laser at 916 nm stabilized to an ultrastable optical resonator exhibiting a thermal noise floor of 3×10^{-16}. For atomic spectroscopy, the light is resonantly frequency doubled (SHG). We give a detailed presentation of our clock laser system and discuss relevant noise sources, especially the influence of the SHG on laser stability.

A 4.6 Mon 11:45 V47.02

Comparison of reference cavities for an optical clock with improved short-term stability — •Jonas Keller[1], Stepan Ignatovich[2], Maksim Okhapkin[1,2], Stephen Webster[3], David-M. Meier[1], Karsten Pyka[1], and Tanja E. Mehlstäubler[1] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [2]Institute of Laser Physics, 630090 Novosibirsk — [3]National Physical Laboratory, Hampton Road, Teddington

Our work is targeted on the development of an optical frequency standard with a relative short term stability below 10^{-15} in 1s based on Coulomb crystals of $^{115}\mathrm{In}^+$ and $^{172}\mathrm{Yb}^+$ ions in a linear segmented Paul trap. This requires two highly stable lasers for interrogating the $^1\mathrm{S}_0 \leftrightarrow {}^3\mathrm{P}_0$ clock transition in $^{115}\mathrm{In}^+$ and the $^2\mathrm{S}_{1/2} \leftrightarrow {}^2\mathrm{D}_{5/2}$ transition in $^{172}\mathrm{Yb}^+$ for studying and controlling the dynamics of the ion crystals. To achieve these stabilities, we are experimentally comparing two different designs for reference cavities with ULE® spacers and fused silica mirrors. A simple setup using a horizontally mounted cavity of 12 cm length yielded a thermal time constant of 44 h and allowed the stabilization of a diode laser to a relative frequency instability of $6 \cdot 10^{-16}$. The second cavity has a length of 30 cm, giving a thermal noise limit of $1 \cdot 10^{-16}$. Its spacer design is based on FEM calculations to ensure a sufficiently low vibration sensitivity. In order to refine this experimentally, the support points can be moved freely along the optical axis. For this adjustment, the short cavity can act as a reference.

A 4.7 Mon 12:00 V47.02

Strontium in an Optical Lattice as a Mobile Frequency Reference — •Ole Kock, Steven Johnson, Yeshpal Singh, and Kai Bongs — University of Birmingham, Birmingham, UK

Using the higher frequencies (10^{15} Hz) of optical atomic transitions for clocks enable a greater accuracy than the current microwave frequency (10^{10} Hz) standard. Optical clocks have now achieved a performance significantly beyond that of the best microwave clocks. With the rapidly improving performance of optical clocks, in the future, most applications requiring the highest accuracy will require optical clocks. We are setting up an experiment aimed at a mobile frequency standard based on strontium (Sr) in a blue detuned optical lattice. Sr is an alkaline-earth element. The dipole transitions in Sr from the singlet state to the triplet state is forbidden, which results in a long meta-stable lifetime and as narrow line widths as one mHz. Compared to other Strontium experiments with Zeeman Slowers our setup implements the first 2D-MOT for pre cooling the atoms. An up to date progress on the 3D-MOT of this compact and robust frequency standard will be given. For the emerging field of optical clocks in space, this project is developing technologies for the Space Optical Clock (SOC2) project.

A 4.8 Mon 12:15 V47.02

Towards spectroscopy of the clock transition of Yb in a magic wavelength optical lattice — •Gregor Mura, Charbel Abou Jaoudeh, Tobias Franzen, and Axel Görlitz — Institut für Experimentalphysik, HHU Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

Optical clocks using neutral atoms hold the promise to eventually reach an inaccuracy at a level of 10^{-18}. So far optical lattice clocks have been demonstrated for Yb, Sr and Hg. Here we report on loading an 1D magic wavelength optical lattice with Yb which is a crucial step towards the realization of a compact and transportable Yb lattice clock. After precooling in a MOT operating at 399 nm a few 10^6 atoms are loaded into a postcooling MOT at 556 nm where a temperature of $\sim 50\,\mu$K is reached. More than 5 % of the atoms can then be transferred into a resonator-based optical lattice. We have achieved a lifetime of a few 100 ms which is sufficient for the operation of an optical clock. The next step will be spectroscopy of the clock transition $6^1S_0 \rightarrow 6^3P_0$ of Yb at 578 nm.