Q 41: Poster – Quantum Technologies II & Laser Technology

Quantum Enabling Technologies; Laser Cooling and Trapping; Laser Technology and Applications

Time: Wednesday 17:00–19:00 Location: Philo 2. OG

Q 41.1 Wed 17:00 Philo 2. OG

Implementation of ground separation boards for DC and RF supply devices in trapped-ion experiments — •Jannik Mattil[1], Shobhit Saheb Dey[1], André Philipp Kulosa[1], Jonas Keller[1], Martin Ludwig Hesse[1,2], Ranjit Kumar Singh[1,2], Nicolas Spethmann[1], and Tanja Mehlstäubler[1,2] — [1]Physikalisch-Technische Bundesanstalt (PTB), 38116 Braunschweig, Germany — [2]Leibniz-Universität Hannover, 30167 Hannover, Welfengarten 1, Germany

Ion traps have matured into commercially available quantum technology products, used in high-precision applications such as optical clocks [1]. These applications demand highly sensitive spectroscopic measurements, making the suppression of perturbations essential. The trap control electronics can couple electro-magnetic noise into the trap electrodes. This electromagnetic field noise originating from inadequate grounding of electronic devices —ground loops— leads to increased motional heating and instability in precision measurements. We report about plug-and-play ground isolation boards designed to separate the DC and RF ground connections explicitly for usage of the Sinara hardware [2]. Three different isolation boards (capacitive, inductive, opto-coupled) have been designed and characterized to identify the best performance in noise suppression via heating rate measurements with trapped ions. [1] Jordan E., Brinkmann M., Didier A., Jansson E., Steinel M., Huntemann N., Shao H., Siebeneich H., Wunderlich C., Johanning M. und Mehlstäubler T. E., Quantum Sci. Technol. 10, 045005 (2025). [2] https://github.com/sinara-hw

Q 41.2 Wed 17:00 Philo 2. OG

Database for UHV and XUHV suitable materials for use in quantum technologies — •Vanessa Galbierz[1], Pascal Engelhardt[1,2], Sofia Herbers[1], and Piet Oliver Schmidt[1,2] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [2]Leibniz Universität Hannover, Institut für Quantenoptik, 30167 Hannover, Germany

The background pressure of a vacuum system is one major limiting factor when it comes to the lifetime and coherence time of atomic quantum systems. Hence, potentially suitable materials for use in such experiments need to be assessed carefully regarding their outgassing behavior. To address this issue, we developed a strategy to identify, measure, and classify applicable materials, thereby assessing their suitability for use in UHV and XUHV environments. Identified materials, as well as subassemblies and commercially available parts, are then collected and indexed into a comprehensive database. We will present the prototype of this database in detail, including the outline structure and first results. We will demonstrate how standardization for the tabulation could work and which information is required to provide the data for even an inexperienced user, highlighting possible use cases and benefits for all types of vacuum-based experiments.

Q 41.3 Wed 17:00 Philo 2. OG

Sub-kHz, RF-traceable Frequency Comb with Dual-Domain Stabilization and Automated Locking — •Ali Seer, Jae-Ihn Kim, Florian Figge, Thomas Puppe, Christoph Stihler, and Matthias Scholz — TOPTICA Photonics SE, Gräfelfing, Germany

We present a dual-loop-stabilized DFG frequency comb providing simultaneous spectral purity and SI-traceable frequency accuracy. The scheme avoids the cost and complexity of high-finesse cavity-stabilized systems while delivering sub-kHz linewidths. A comb-comb comparison demonstrates an H-maser-like long-term stability limit. Fully automated locking and a unified GUI make the system a universal optical reference for quantum-optics experiments.

Q 41.4 Wed 17:00 Philo 2. OG

MEMS scanner mirrors for integration of an optical cavity in an ion trap — •Can Leichtweiss[1], Paul Raschdorf[2], Jan Müller[1], Jonas Vogel[1,3], Janine Hilder[1,3], Björn Lekitsch[1,3], Shanshan Gu-Stoppel[2], and Ferdinand Schmidt-Kaler[1,3] — [1]QUANTUM, Institut für Physik, 55128 Mainz — [2]Fraunhofer-Institut für Siliziumtechnologie, 25524 Itzehoe — [3]neQxt GmbH

The high fidelity readout of trapped ion qubits is based on the observation of laser-induced fluorescence. However, photons are randomly scattered in angle, which reduces the collection efficiency and increases the time required for readout. We plan to use the Purcell effect by deploying a resonant optical cavity such that photons are scattered into the cavity mode, which in turn could reduce the qubit detection time to a few μs.

We fabricate and test MEMS mirror devices, which allow for length stabilization and alignment of a high finesse cavity. We will position the cavity waist to the ion position without moving the ion itself, avoiding excess micromotion. Furthermore, a small footprint is required for an integration to an ion trap. We report results from a cavity with a ion-mirror distance of 0.8 mm, characterizing the finesse, waist size and adjustment features. In future, and with enhanced coupling [1], such cavity-enabled ion-light interface may allow for interconnecting trapped ion quantum processor modules.

[1] Takahashi, et al. *PRL* **124**, 013602 (2020)

Q 41.5 Wed 17:00 Philo 2. OG

Simulation-Based Approach for Programming a Spatial Light Modulator for Deterministic fs-Laser Writing of NV-Centers in Diamond — •Julian Staniewski[1], Lucas Kirchbach[1,2], Andreas Giese[2], Bernd Braun[2], and Andreas Stute[1,2] — [1]Faculty of Electrical Engineering, Precision Engineering, Information Technology, Technische Hochschule Nürnberg, Keßlerplatz 12, 90489 Nürnberg — [2]Faculty of Applied Mathematics, Physics and Humanities, Technische Hochschule Nürnberg, Keßlerplatz 12, 90489 Nürnberg

To generate deterministically placed vacancies in a diamond crystal, a high spatial-temporal energy density must be achieved in the crystal. Consequently, the wavefront of a fs-laser shall be corrected via a spatial light modulator (SLM) prior to entering the high numerical aperture focusing optics. This work presents an optical model that allows for calculating the phase mask to be imposed by the SLM. To validate the accuracy of the model, crystal samples of different thickness are used in a test setup to intentionally introduce aberrations. The model is verified via comparing such wavefront measurements with the model predictions.

Q 41.6 Wed 17:00 Philo 2. OG

Highly-efficient, low noise quantum frequency conversion of single photons from a tin-vacancy center in diamond — •Marlon Schäfer, David Lindler, Tobias Bauer, and Christoph Becher — Universität des Saarlandes, Campus E2 6, 66123 Saarbrücken

Quantum frequency conversion (QFC) is a key enabling technology for quantum repeaters and large-scale quantum networks, as it connects quantum memories with optical transitions in the visible and near-infrared spectrum to the low-loss telecommunication bands used in optical fiber networks. Here, we demonstrate a highly efficient and low-noise QFC device for single photons resonant with tin-vacancy (SnV) centers in diamond. Using difference-frequency generation in periodically poled lithium niobate waveguides, single photons at 619 nm are mixed with a strong 2062 nm pump beam to generate light at an intermediate wavelength of 885 nm, followed by a second conversion stage to 1550 nm. This two-step conversion scheme strongly suppresses noise from pump-induced spontaneous parametric processes as well as Raman scattering, resulting in an exceptionally low noise level of less than 4 photons per second per gigahertz of filter bandwidth. In addition, the device achieves a fiber-to-fiber conversion efficiency of 45%, including an 8 GHz bandwidth filtering stage. Measurements of second-order correlation functions for the converted photons confirm the preservation of nonclassical photon statistics after frequency conversion.

Q 41.7 Wed 17:00 Philo 2. OG

Comparison of High-Precision PM-Fiber Alignment Methods for Integrated Photonic Devices — •Philipp Will[1], Lucas Kirchbach[1,2], Alexander Bachmann[3], Rainer Engelbrecht[1,3], and Andreas Stute[1,2] — [1]Technische Hochschule Nürnberg, faculty efi, Nuremberg, Germany — [2]Technische Hochschule Nürnberg, faculty amp, Nuremberg, Germany — [3]Technische Hochschule Nürnberg, Polymere Optical Fiber Application Center (POF-AC), Nuremberg, Germany

This work compares three experimental methods for determining the rotation angle and position of polarization-maintaining fibers for use in integrated fiber arrays: detection of the front-face panda structure, polarization measurements of the light guided by the fiber, and imaging the panda structures via the lateral view of the fiber. Position and rotational angle of the PM fiber are detected via image recognition algorithms. Achieved positional accuracies lie in the sub-micrometer range, rotational accuracies in the range of 0.01 rad corresponding to a polarization extinction ratio of > 40 dB.

Q 41.8 Wed 17:00 Philo 2. OG

Characterization of photonic qubit conversion from polarization to time-bin in the telecom range — •Julian Gross-Funk[1,2], Christian Haen[1], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken, Germany — [2]see below

Many photonic quantum memory implementations rely on the time-bin degree of freedom, which protects against decoherence in fiber transmission, in contrast to polarization encoding. Time-bin qubits, however, lack compatibility with photonic polarization qubit implementations, such as single photons emitted by single trapped ions [1].

In this poster, we present a fiber-based converter for photonic 1550 nm polarization qubits to the time-bin degree of freedom, enabling quantum experiments between different platforms. The fundamental setup is based on an unbalanced interferometer for conversion and a second one for measurement and reconstruction of the converted states. The 18 m imbalance of the interferometer arms induces a sensitivity to temperature variations in the millikelvin range, that we compensate by an active temperature and phase stabilization scheme based on a reference laser beam.

We investigate the influence of the temperature on the reconstruction fidelity, characterize the device by its ability to preserve the quantum information and evaluate its performance with regard to other applications.

[1] M. Bock et al., Nature Commun. 9, 1998 (2018).

[2]presently at German Aerospace Center (DLR), Institute of Quantum Technologies, 89081 Ulm, Germany

Q 41.9 Wed 17:00 Philo 2. OG

Cryogenic integrated circuits for scalable trapped-ion based quantum computers — •Sebastian Halama[1], Marco Bonkowski[1], Peter Toth[2], Alexander Meyer[2], Marius Neumann[3], Vadim Issakov[2], and Christian Ospelkaus[1,4] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Institut für CMOS Design, Technische Universität Braunschweig, Hans-Sommer-Straße 66, 38106 Braunschweig, Germany — [3]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Technische Universität Braunschweig, Hans-Sommer-Straße 66, 38106 Braunschweig, Germany — [4]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

State of the art quantum computers are still too small and have a too high error rate to tackle any useful problem. Surface-electrode ion traps are a promising platform to overcome both issues. However, with increased size the number of required electrical signal grows. Specially for cryogenic vacuum chambers, this will eventually result in a non tolerable heat load originating from cables. A possible solution is to hybrid-integrate control electronics together with the ion trap [1, 2]. This can potentially reduce the number of externally applied control signals to only a few, while it is still possible to supply hundreds of electrodes with suitable voltages. We present our latest work on integrating DC and microwave generators with a cryogenic ion trap.

[1] A. Meyer et al., DOI: 10.1109/TIM.2025.3571087
[2] P. Toth et al., DOI: 10.1109/ISSCC49661.2025.10904696

Q 41.10 Wed 17:00 Philo 2. OG

Sub-natural linewidth absorption filter based on Raman resonance in hot atomic vapour — •Viola-Antonella Zeilberger[1], Inna Kviatkovsky[1], Lucas Pache[1], Leonid Yatsenko[2], Philipp Schneeweiss[1], Jürgen Volz[1], and Arno Rauschenbeutel[1] — [1]Institute of Physics, Humboldt University of Berlin, Berlin, Germany — [2]Institute of Physics, National Academy of Sciences of Ukraine, Kyiv, Ukraine

Narrow optical band-stop filters are essential for fundamental research and a wide range of photonic technologies, including quantum memory and low-frequency Raman spectroscopy. Experimentally, narrow absorption features are realised using optical resonators or Faraday filters. In this work, we present an experimental realisation of a sub-natural linewidth filter based on Raman resonance in hot ^{87}Rb vapour. The filter builds on a three-level lambda scheme on the D1 line, where two optical fields couple the hyperfine ground states to a common excited state. By driving Raman transitions at single-photon detunings larger than the Doppler width of the atomic vapour, we are able to obtain absorption features in the kilohertz regime, well below the natural linewidth. We further investigate the influence of buffer gas and the addition of a repump field for achieving higher optical depth. This implementation of an optical notch-filter combines the advantages of a spectral narrow-band absorption window with high off-resonant transmission and thus can be crucial for applications where narrow spectral features have to be attenuated without affecting the rest of the spectrum.

Q 41.11 Wed 17:00 Philo 2. OG

Zerodur-Based Compact Laser and Vacuum Systems — •Bojan Hansen[1], Nora Bidzinski[1], Robin Lelewel[1], Takeshi Matsuyama[1], David Latorre Bastidas[2], André Wenzlawski[2], Patrick Windpassinger[2], Ortwin Hellmig[1], and Klaus Sengstock[1] — [1]Institute for Quantum Physics, University of Hamburg, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany

Adapting ultra cold atom experiments for portable applications demands strict constraints on size, energy consumption, and environmental resilience. We present a compact, energy-efficient Zerodur-based MOT laser system that employs optical cavities as frequency references not only for fast frequency switching but also for stabilising the cooling and repumping lasers against a laser with an atomic reference. This approach significantly reduces system footprint, enhances energy efficiency, and introduces redundancy and autonomy. Complementing this, we develop a flange-free, ultra-portable Zerodur vacuum chamber operating without an active getter pump. Together, these innovations advance the realisation of robust, compact, and portable quantum devices, potentially fitting within a shoebox-sized form factor.

Q 41.12 Wed 17:00 Philo 2. OG

Packaging of All-Laser-manufactured Vapor-cell for Interposer integrated Quantum sensing — •Patrick Hildebrand, Yassin Nasr, Veronica Montoya, Thilo Danner, Andreas Michalowski, and Tobias Menold — University of Stuttgart, Institut für Strahlwerkzeuge (IFSW), Stuttgart, Germany

This work presents a concept for a fully laser-fabricated, photonic-integrated vapor cell intended for compact quantum sensors such as chip-scale magnetometers and gyroscopes. The approach combines femtosecond direct writing for waveguide formation with Selective Laser Etching (SLE) to create the vapor-cell cavity and internal micro-optics. Elements such as micromirrors and integrated miniature lenses are designed to reduce coupling losses between the waveguides and the vapor cell as well as to a flip-bonded laser diode and photodiode. Laser-based bonding is proposed for hermetic sealing without mechanical alignment or additional materials.

Compared with conventional MEMS vapor cells relying on free-space optics, this glass-based architecture embeds all optical paths directly into the substrate, eliminating external alignment components and reducing sensitivity to vibration and temperature variations. Combining waveguide writing, cavity formation, micro-optics fabrication, and bonding into a single laser-based process chain is expected to simplify assembly and improve reproducibility. The concept outlines a path toward integrated vapor-cell modules that are robust, compact, and scalable for industrial production.

Q 41.13 Wed 17:00 Philo 2. OG

Towards time-reversing an exponentially rising pulse with a single ground state cooled ^{174}Yb^{+} ion — •Sebastian Luff[1,2], Hans Dang[1,2], Martin Fischer[1], Markus Sondermann[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

Deterministic excitation of a single ion by a single photon can be realized when the temporal envelope of the photon matches the time-reversed waveform of a spontaneously emitted photon from the same atomic transition [1]. In this work, we implement such a scheme by sending an exponentially rising pulse onto a ^{174}Yb^{+} ion, driving its strong dipole transition (370 nm wavelength, 8.1 ns life time). To enhance the photon-ion coupling efficiency, the ion is positioned inside a deep parabolic mirror that covers nearly the full solid angle of the incident light field [2]. This geometry enables near-maximal spatial mode overlap between an incident doughnut-shaped mode and the ion's dipole radiation pattern. Furthermore, the ion is cooled well below the Doppler limit through resolved sideband cooling, reducing its spatial extent to a size smaller than the focal spot of the parabolic mirror. We report on our progress towards achieving the maximum coupling possible with this system.

1. Leuchs, G. & Sondermann, M. Phys. Scr. 85, 058101 (2012).
2. Maiwald, R. et al., Phys. Rev. A 86, 043431 (2012).

Q 41.14 Wed 17:00 Philo 2. OG

Parallel cryogenic setups for scalable quantum computation with surface ion traps — •Marco Schmauser[1], Marco Valentini[1], Eric Kopp[1], Michael Pasquini[1], Jakob Wahl[1], Andreas Wendl[2], Philip Holz[3], Josef Schupp[3], Philipp Schindler[1], Thomas Monz[1,3], and Rainer Blatt[1] — [1]Inistitut für Experimentalphysik, Universität Innsbruck, Austria — [2]kiutra, Munich, Germany — [3]Alpine Quantum Technologies, Innsbruck, Austria

Trapped-ion (TI) quantum systems are promising candidates for future quantum computing applications. TI devices based on macroscopic linear Paul traps are practically limited to a maximum of 30 ions. Microfabricated surface traps are an alternative approach that allow for improved scalability though modular design, integrated optics, and additional electronic trap layers.

Here we present the implementation of parallel cryogenic setups, one rack-based, and one table-based for rapid testing and characterization of such surface traps. Each setup features an independent cryostat able to cool to a base temperature of 5K within 12 hours. Trap integration is realized via a standardized socket interface, reducing trap exchange time to approximately 2 hours. The setups feature 128 (100) DC electrodes, 6 RF electrodes, 21 in-vacuum fibers for 40Ca+ wavelengths, and two independent resonators to enable concurrent axial and radial shuttling. The rack-based setup additionally features a novel hermetic interface to facilitate rapid swapping of vacuum chambers without venting, thus minimizing experimental downtime.

Q 41.15 Wed 17:00 Philo 2. OG

Quantum characterization and control of single molecules — •Max Koppelstätter — Universität Innsbruck, Innsbruck, Austria

The QCosmo team studies quantum states and dynamics in trapped polyatomic molecular ions with quantum logic spectroscopy (QLS). This method maps molecular transitions to a co-trapped atomic logic ion, enabling robust and efficient state readout. We focus on novel spectroscopy techniques, rovibronic state preparation and control, and the possibilities and limitations of applying quantum information processing techniques to molecular ions. We have recently measured the infrared vibrational transition frequency in the OH stretch mode of a single trapped $CaOH^+$ molecular ion using cat state recoil spectroscopy. This method uses cat states to amplify the detection of the recoil of a single absorbed photon via an accumulated geometric phase. We are also developing Raman QLS to enable molecular hyperfine and rotational spectroscopy and control. Ongoing work includes planning and development of a second-generation cryogenic experiment with a segmented ion trap. The segmented design enables axial control for optimal ion positioning, while the cryogenic environment suppresses quantum jumps from thermal radiation and background gas collisions, extending ion storage and coherence times. Another component currently under development is the ion-injection system, which introduces molecular ions into the cryogenic environment.

Q 41.16 Wed 17:00 Philo 2. OG

A laser system for cooling 87Rb atoms in an optical cavity — •Daniel Reigel, Luis Weiss, Sebastián Alejandro Moralez Ramirez, Raphael Benz, Micha Kappel, Maurizio Trigilia, Vincent Beguin, Leon Layer, Violet Ruf, and Stephan Welte for the QNN-Collaboration — 5. Physikalisches Institut, Center for Integrated Quantum Science and Technology and CZS Center QPhoton, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Arrays of neutral atoms at the center of an optical cavity are a promising platform for implementing quantum-coherent network nodes, which can be interconnected using flying optical photons. To prepare such a system, laser-cooling techniques are required to cool the atoms, such that they can be trapped in optical potentials. We present our laser setup for cooling neutral 87Rb atoms in a magneto-optical trap (MOT). This serves as a source of cold atoms for the planned experiments. Our cooling laser is locked to an ultra-low-expansion (ULE) cavity. We describe our locking scheme as well as the subsequent acousto-optic modulators used to tune the lasers to the respective cooling transitions. We also present the development and implementation of a two-dimensional MOT that relies on the laser system described above. In the planned experiments, we aim to generate an intra-cavity atom-tweezer array with individual-atom addressing. We designed a 2D MOT in a glass cell attached to the main chamber. We discuss the design of the components of this MOT, and the mechanical mounting of our dispensers in the glass cell. Finally, we provide an outlook on the planned experiments with the new quantum-network setup.

Q 41.17 Wed 17:00 Philo 2. OG

Atomic Dynamics in Time-Dependent Optical Dipole Traps using GPU Computing — •Paul Christ and Reinhold Walser — Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4A, 64289, Darmstadt

We investigate the classical non-equilibrium dynamics of neutral ^{87}Rb atoms confined in optical dipole traps. Motivated by experiments in the group of Prof. Birkl at TU Darmstadt [1,2], our work focuses on a crossed-beam dimple trap geometry, where a deep, tightly confining potential minimum at the beam intersection is used to enhance phase-space density. This will lead to the reversible creation of a Bose-Einstein condensate (BEC).

To optimize the evaporative cooling, we implement time-dependent potentials that accurately describe the dynamic lowering of the trap depth. The project utilizes classical molecular dynamics (MD) simulations using Graphics Processing Units (GPUs). The evaluation of the binary forces acting on a particle benefits significantly from the massive parallelization. To ensure long-term numerical stability and energy conservation, we employ and compare higher-order symplectic integration algorithms.

From the MD simulation, we find the relaxation dynamics (collision rates, scaling laws and thermodynamic relations) of the gas and obtain the critical experimental parameters.

[1] D. Pfeiffer, Dissertation TU Darmstadt, 10.26083/tuprints-00031145, (07/2025)
[2] T. Lauber et al., Phys. Rev. A **84**, 043641 (2011)

Q 41.18 Wed 17:00 Philo 2. OG

Pulsed UV Laser System for Laser Cooling of Relativistic Bunched Ion Beams — •Harri Lara[1], Tamina Grunwitz[1,2], Benedikt Langfeld[1,2], and Thomas Walther[1,2] — [1]TU Darmstadt — [2]HFHF Campus Darmstadt

At FAIR's synchrotron SIS100, laser cooling is the planned method for narrowing the momentum distribution of relativistic bunched ion beams. Due to the specific demands of the SIS100, three lasers will be used: Two pulsed lasers for pre-cooling that can address ions over a wide range of velocity classes due to their spectral width and one continuous wave laser to further cool the ions to the coldest temperatures.

In this contribution, we present our pulsed UV laser system with a centre wavelength of 257 nm. For the purposes of laser cooling application, the UV pulsed system produces pulses between 46 and 734 ps with a repetition rate between 1 and 10 MHz. Additionally, an average power output of 5.3 W has been achieved at 257 nm. Since the construction of this pulsed laser system, we have begun to duplicate it for use at the SIS100 and we will also present the progress made on the development of this duplicated system.

Q 41.19 Wed 17:00 Philo 2. OG

Towards ground state cooling of $^{115}\mathrm{In}^+ - ^{172}\mathrm{Yb}^+$ Coulomb crystals — •Mouhamed-Omar Manai[1,2], Ingrid M. Richter[1], H. Nimrod Hausser[1], Shobhit S. Dey[1], Dongliang Cong[1], Jonas Keller[1], and Tanja E. Mehlstäubler[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Leibniz Universität Hannover, Hanover, Germany

One of the major contributions to the error budget of state-of-the-art optical clocks is second-order Doppler shift, also referred to as time dilation (TD) shift. Ground-state (GS) cooling of the clock ions not only suppresses this TD shift as well as line broadening beyond what is achievable with Doppler cooling alone, but also allows for the manipulation of the motional state by single quanta.

Our multi-ion clock features a mixed-species Coulomb crystal trapped in a radiofrequency Paul trap [1]. Clock campaigns have been conducted with up to eight $^{115}\mathrm{In}^+$ clock ions, which are sympathetically cooled by twelve $^{172}\mathrm{Yb}^+$ ions. The systematic uncertainty in this configuration is at the 1×10^{-18} level, with TD shift being one of the limiting contributions.

We are currently implementing GS cooling on the $^1S_0 \rightarrow {}^3P_1$ intercombination transition of In^+, in an intermediate regime with a linewidth of $\gamma = 360\,\text{kHz}$. This will allow for spectroscopic investigations of the TD shift, in turn allowing us to further reduce our clock uncertainty, along with tests of relativity.

[1] H. N. Hausser et al., Phys. Rev. Lett. 134, 023201 (2025)

Q 41.20 Wed 17:00 Philo 2. OG

Rotational state preparation of $CaOH^+$ — •Miriam Kautzky, Brandon Furey, Zhenlin Wu, Mariano Isaza-Monsalve, Tim Duka, Max Koppelstätter, and Philipp Schindler — Institut für Experimentalphysik, Universität Innsbruck, Austria

Molecules possess complex degrees of freedom not available in atoms, making them excellent systems for testing fundamental physics through spectroscopy of their internal structure. Their quantum mechanical rotation is a potential resource for quantum technologies and enables quantum error correction (QEC) codes that protect against spontaneous decay. Preparing molecules in pure rotational states is essential for implementing such codes and for spectroscopic methods relying on quantum logic. We aim to cool molecules to low rotational levels and prepare specific rotational levels with Raman interactions. We are developing an experimental setup to achieve rotational level cooling and level preparation of $CaOH^+$ ions with spectrally shaped broadband laser pulses on a vibrational transition. Spectral shaping enables rotational cooling by driving only specific rovibrational transition bands and thus allowing selective population transfer. It requires precise control of the laser spectrum to target only P-branch transitions. While rotational ground-state cooling has previously been demonstrated, precise control over rotational states, particularly in polyatomic molecules, remains less explored. Achieving this control could enable exploration of quantum information processing and QEC with trapped molecular ions.

Q 41.21 Wed 17:00 Philo 2. OG

KOAQS – novel design for compact cold-atom sources — •Constantin Avvacumov, Alexander Herbst, Wei Liu, Ashwin Rajagopalan, Knut Stolzenberg, Daida Thomas, Ernst M. Rasel, and Dennis Schlippert — Leibniz Universität Hannover, Institut für Quantenoptik

Atom interferometers are powerful instruments for fundamental research and geodesy, including applications such as gravimetry. Quantum projection noise and the demand for high sampling rates motivate the development of new high-flux sources of cold atoms. The typical first atom cooling stage of atom interferometers is a two-dimensional magneto-optical trap (2D-MOT). Recent efforts to reduce the SWaP (size, weight and power) of 2D-MOTs have raised questions about the feasibility of integrating optics more closely into the vacuum chamber and the long-term compatibility of high-reflectivity optical coatings exposed to alkali vapor such as potassium or rubidium.

In this poster, we present KOAQS (Kompakte Atomquelle für Quantensensoren) – a novel high-flux 2D-MOT design with improved SWaP characteristics. To ensure long-term performance, we conduct a systematic analysis of the interaction between Rb vapor and various highly reflective coating materials using accelerated aging tests. The best-performing mirror type is implemented in our 2D-MOT, and we present its functionality and characterization of its performance.

Q 41.22 Wed 17:00 Philo 2. OG

Optimierung des Kopplungslasers zur Vorbereitung auf LWI im UV-Bereich — •Tobias Neumann, Thorsten Führer und Thomas Walther — TU Darmstadt

Lasing without Inversion (LWI) stellt einen vielversprechenden Ansatz zur Erzeugung kohärenter Strahlung im UV- und VUV-Bereich dar, wobei auf die hohen Pumpintensitäten konventioneller Laserquellen verzichtet werden kann. Frühere Arbeiten im Quecksilber-Vier-Niveau-System identifizierten dabei entscheidende Parameter für Amplification without Inversion (AWI)[1]. Um diese zu erreichen, ist insbesondere eine höhere Leistung des Kopplungslasers bei 435,8 nm erforderlich. Aus diesem Grund wird derzeit ein umfassender Neuaufbau dieses Lasersystems umgesetzt. Gemäß dem neuen Konzept ist eine vollständige Entkopplung der Regelkreise für Frequenzstabilisierung und Frequenzverdopplung vorgesehen. Die für die Frequenzstabilisierung erforderliche 435,8-nm-Strahlung wird durch Single-Pass-Frequenzkonversion erzeugt, während die für das AWI-Experiment relevante Verdopplung in einem Überhöhungsresonator stattfindet. Darüber hinaus werden Steuerungs- und Elektronikhardware modernisiert, um die Stabilität und Langzeitzuverlässigkeit zu erhöhen. Die Implementierung dieser Maßnahmen zielt darauf ab, die Rahmenbedingungen für zukünftige AWI- und LWI-Messungen im UV-Bereich zu ermöglichen. Es werden erste Ergebnisse des neu aufgebauten Lasersystems sowie der nächsten experimentellen Schritte präsentiert.

[1] Daniel Preißler (2024) doi.org/10.26083/tuprints-00027578

Q 41.23 Wed 17:00 Philo 2. OG

Continuous Wave UV Laser System for Cooling Relativistic Bunched Ions — •Denise Schwarz[1], Jens Gumm[1], and Thomas Walther[1,2] — [1]Technische Universität Darmstadt — [2]HFHF Darmstadt

Bunched relativistic ion beams with a narrow momentum distribution are essential for precision experiments at modern accelerator facilities. Laser cooling presents a promising approach to further reduce the relative momentum distribution of such ion beams.

This work presents the high power UV cw laser system for laser cooling at the SIS100 at FAIR. The laser system can be scanned without experiencing mode-hops over 25 GHz in the infrared. In two cavities, frequency conversion is employed to achieve the necessary wavelength of 257 nm for laser cooling. The second enhancement cavity employs an elliptical focus to avoid degradation of the BBO crystal while achieving a high an stable output in the UV.

Q 41.24 Wed 17:00 Philo 2. OG

Laser frequency noise measurement close to the shot noise limit — •Christoph Raab[1], Jonas Vogel[3], Björn Lekitsch[3], and Ferdinand Schmidt-Kaler[2,3] — [1]Hochschule Darmstadt, Darmstadt, Germany — [2]QUANTUM, Universität Mainz, Mainz, Germany — [3]neQxt GmbH, Erlenbach, Germany

Frequency-stabilized laser sources are used in many industrial or scientific applications like spectroscopy, frequency standard, interferometry and quantum technology. Typically, the freqency noise of a source is characterized by a beat note with a second laser. Here, we present a measurement setup to precisly characterise the frequency and phase noise of a cw laser without this significant overhead. The setup employes an interferometric approach to convert frequency fluctuations into an amplitude signal, detected by a photo diode. We find that the noise limit of the interferometer is dominated by the detection noise. Therefore, we carefully select and optimize the photodetector and the digitizing system, reaching a lower limit for the frequency noise density of a few Hz^2/Hz or an equivalent laser linewidth of about 10 Hz. Our setup is optimzed for laser sources in the wavelength range of 620 nm to 870 nm, but the setup can be adapted over the entire range of visible to IR wavelengths.

Q 41.25 Wed 17:00 Philo 2. OG

Active Feedback for relative intensity noise reduction in solid-state lasers — •Thomas Konrad[1], Tobias Steinle[1], Roman Bek[2], Michael Scharwaechter[2], Matthias Seibold[2], Andy Steinmann[1], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart — [2]Twenty-One Semiconductors GmbH, Stuttgart

Fast and precise measurements are key for many challenging laser applications, such as biological and biomedical imaging. The precision is limited by the noise of the systems we use. Once the measurement precision reaches the laser noise level, the measurement time must be increased quadratically for further improvement. Especially with biological samples, a significant longer measurement time can alter the specimen and/or results. Therefore, exploiting the optimum noise characteristic of the driving source is superior to increasing measurement time. In this work, we investigate noise reduction of a solid-state laser in the spectroscopically relevant 1 kHz - 10 MHz frequency range. Our approach differs from traditional subsequent noise eaters, since we reduce the noise within the laser oscillator itself. In contrast to comparable commercial solutions with monolithic crystal oscillators, we use a free space cavity with two gain materials. To compensate the noise of our laser, we use a second high-speed gain medium in the cavity whose pump is modulated by a PID feedback loop, while the main medium remains constantly pumped. So far, we achieved a noise reduction of more than 18 dBc/Hz at the relaxation oscillation frequency.

Q 41.26 Wed 17:00 Philo 2. OG

Development of cw laser systems in the deep-UV and vacuum-UV ranges — •Jonas Gottschalk[1], Lukas Möller[1], Björn-Benny Bauer[1], Felix Waldherr[1], Sascha Haider[1], Thorsten Groh[1], Stephan Hannig[2], Stefan Truppe[3], Sid Wright[4], Simon Stellmer[1], and UVQuanT Consortium[1] — [1]Universität Bonn, Germany — [2]Agile Optics GmbH — [3]Imperial

College London — [4]Fritz Haber Institute of the Max Planck Society

Reliable and tunable ultraviolet (UV) laser sources are increasingly important for applications in spectroscopy and precision metrology, yet many UV wavelengths remain difficult to access efficiently.

We present a set of UV laser systems that employ cascaded sum-frequency-generation (SFG) stages in nonlinear crystals using different phase matching schemes.

The fundamental light is provided by Diode, VECSEL and Ti:Sa lasers.

The SFG stages are implemented in both single-pass and cavity-enhanced configurations, including one system employing an elliptical cavity mode.

The resulting systems deliver stable, narrowband radiation across multiple regions of the UV spectrum, from 185 nm to 310 nm, demonstrating a versatile and scalable platform for advanced UV laser generation.

Q 41.27 Wed 17:00 Philo 2. OG

Automated Calibration of a MZI-Mesh based Optical Computer — •Okan Akyüz[1], Konrad Tschernig[1], Mingwei Yang[1,2], Felix Kübler[1], Lennart Mannteuffel[1], Enrico Stoll[1], and Janik Wolters[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Weltraumforschung, Berlin, Germany

Optical computing uses light instead of electronic signals for computation, with hardware such as Mach-Zehnder-interferometer (MZI)-based systems that implement programmable linear optical networks. A major challenge is individually calibrating each unique phase shifter for applications ranging from Vector-Matrix Multiplication (VMM)[1] to quantum computation[2]. In this work, we demonstrate the automated calibration of a 12x12-mode MZI-mesh based optical processor. We use external optical switches to feed a laser into input ports and measure the output intensity from the corresponding output ports. A tailored algorithm allows isolating the effect of each of the 132 phase shifters and determining the heating power to phase calibration. After isolating each phase shifter, we can perform a voltage sweep to determine the voltage-to-phase calibration curve. We give an outlook on how this calibration can be used to realize efficient optical VMM in machine learning problems.

[1] Shen, Y., et al. Deep learning with coherent nanophotonic circuits. Nature Photon 11, 441-446 (2017).

[2] Sergei Slussarenko, et al.; Photonic quantum information processing: A concise review. Appl. Phys. Rev. 1 December 2019.

Q 41.28 Wed 17:00 Philo 2. OG

Progress of the BECCAL Laser System for Cold Atom Experiments onboard the ISS — •Hamish Beck[1], Hrudya Thaivalappil Sunilkumar[1], Marc Kitzmann[1], Christoph Weise[1], Bastian Leykauf[1], Evgeny Kovalchuk[1], John Davenport[1], Jakob Pohl[1], Achim Peters[1], and the BECCAL Collaboration[1,2,3,4,5,6,7,8,9,10] — [1]HUB, Berlin — [2]FBH, Berlin — [3]JGU, Mainz — [4]LUH, Hanover — [5]DLR-SI, Hanover — [6]DLR-QT, Ulm — [7]UULM, Ulm — [8]ZARM, Bremen — [9]DLR, Bremen — [10]DLR-SC, Braunschweig

The Bose-Einstein Condensate and Cold Atom Laboratory (BECCAL) is designed for operation onboard the International Space Station (ISS). This multi-user facility will enable experiments with Rb and K ultra-cold atoms and BECs in mircogravity. Fundamental physics will be explored at longer time- and lower energy-scales compared to those achieved on earth.

The BECCAL laser system is comprised of micro-integrated diode lasers, miniaturized free-space optics on Zerodur boards, and a system of fibres to bring light to the physics package. The design is subject to strict size, weight, and power (SWaP) constraints, and the operation of the system is supported by extensive ground-based systems.

The ground-based systems built for validation and testing will be presented alongside the design of the flight model.

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