# Q 48: Poster – Quantum Optics, Technologies, and Optomechanics

Time: Wednesday 17:00–19:00 Location: Tent

Q 48.1 Wed 17:00 Tent

**Spatial photon correlations using nearly dead time free ultra-high throughput single photon detection** — Verena Leopold[1,2], Sebastian Karl[1], Jean-Pierre Rivet[3], Stefan Richter[1,2], •Iurii Datii[1], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, FAU Erlangen, Germany — [2]Photonscore GmbH, Magdeburg, Germany — [3]Observatoire de la Côte d Azur, Nice, France

Intensity interferometry recently benefitted from the improvements in single photon detection instrumentation. In this talk we present HBT measurements with a new kind of single photon detectors using a micro channel plate photo multiplier tube. The so called LINPix from Photonscore features an integrated constant fraction discriminator and enables a quantum efficiency of greater than 35% at a wavelength of 405 nm. Together with a matching time to digital converter (TDC), LINTag from Photonscore, the detection system is able to operate at ultra-high count rates of up to 100 MHz and at the same time maintains a very high timing resolution $<$50ps. With this setup, previously tested in the lab, we were able to perform spatial photon correlations of Vega at the C2PU telescope (15m baseline) at the Calern observatory, Nice, France.

Q 48.2 Wed 17:00 Tent

**Multiplexing Color Centers in Silicon Carbide for Quantum Networks** — •Sushree Swateeprajnya Behera[1,2], NienHsuan Lee[1,2], Jonah Heiler[1,2], Jonas Schmid[1,2], Leonard K.S. Zimmermann[1,2], Flavie Davidson-Marquis[1,2], Stephan Kucera[1], and Florian Kaiser[1,2] — [1]Luxembourg Institute of Science Education and Research (LIST), 4362 Esch-sur-Alzette Luxembourg — [2]University of Luxembourg, 4365 Esch-sur-Alzette, Luxembourg

Color centers in wide-bandgap semiconductors have developed as promising candidates for solid-state quantum emitters. Current experimental setups often rely on complex and resource-intensive cryogenic systems to control individual color centers. To address this challenge, we propose a scalable approach to multiplex divacancy color centers in silicon carbide within a single cryostat. Our strategy involves integrating confocal microscopy and fiber array coupling to efficiently interface multiple color centers with our photonic quantum chips. By leveraging the unique properties of color centers, we aim to implement multiplexed spin-photon entanglement experiments at the interface. This advancement will pave the way for the realization of large-scale quantum networks and quantum communication protocols.

Q 48.3 Wed 17:00 Tent

**Custom Shack-Hartmann Sensor for Stellar Intensity Interferometry** — •aleena nedunilath thomas, verena leopold, sebastine karl, and joachim von zanthier — AG Quantum Optics and Quantum Information, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany

For stellar intensity interferometric measurements using single photon counting detectors and ultra narrow interference filters it is crucial to monitor the collimation of the wavefront. We therefore introduce a custom Shack-Hartmann wavefront sensor to monitor the collimation of our beam inside the optical setup during the observations at the telescope. The sensor is made of a Thorlabs fused silica microlens array (MLA150-7AR) with square lenslets focusing onto a ZWO ASI CMOS camera. The camera images are analysed using a self-developed software measuring slope deviations and calculating Zernike polynomial coefficients. The software employs a gradient-fitting algorithm optimised for square lenslet arrays, extracting critical lower-order Zernike coefficients. As a direct application for further observations the defocus coefficient was linked to the displacement of the secondary mirror of the telescope. This way the defocus can be directly optimised during the measurements.

Q 48.4 Wed 17:00 Tent

**Towards spatial magnetic field mapping with electrodynamically trapped NV center diamonds for quantum technology applications at ambient conditions** — •Apurba Das, Deviprasath Palani, Florian Hasse, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg i. Br.

Electro-dynamically trapped micro-diamonds with Nitrogen-Vacancy (NV) center defects offer a suitable platform for fundamental studies. Protected by the diamond crystal, the NV center quantum system can act as a robust quantum sensor for harsh environments. The use of a Stylus Paul trap[1] enhances the accessibility of the trapped systems to external fields, enabling precise control and manipulation of electronic (and motional) degree of freedom. We report our work using trapped micro-diamonds on a Stylus trap for magnetic field mapping, building upon previous works on scanning probe magnetometry. Operating at room temperature and ambient pressure, we use optical trapping techniques to deterministically load diamonds onto the Stylus trap. By customizing the trapping potential, we demonstrate controlled transport of diamonds to specific positions and precise local magnetic field scanning, inspired by prior work with trapped ions[2]. Our work combines nanotechnology's robustness with the precision of AMO physics, advancing scanning probe magnetometry and opening new possibilities for quantum sensing applications at ambient conditions.

[1] R. Maiwald et al, Nat. Phys 5, 551-554(2009)
[2] D. Palani et al, PRA 107, L050601(2023)

Q 48.5 Wed 17:00 Tent

**Experiments towards strong coupling in an atom-optomechanical hybrid system** — •Felix Klein[1], Jakob Butlewski[1], Alexander Schwarz[2], Klaus Sengstock[1], Roland Wiesendanger[2], and Christoph Becker[1] — [1]Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Institute for Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The advancement of modern quantum physics has catalyzed the development of hybrid quantum systems, which combine distinct quantum platforms to leverage their individual strengths. We present our latest results on achieving strong hybrid coupling between a micromechanical $Si_3N_4$ trampoline resonator and laser-cooled $^{87}Rb$ atoms. This coupling is mediated via a coherent light field, which reflects off the resonator to form an optical 1D lattice potential for the atoms. The optical losses along the beam path create an asymmetrically pumped lattice, inducing atomic density waves that destabilize the coupling for attractive lattice potentials. Implementing a compensation lattice allowed access to the attractive coupling regime, achieving a maximal cooperativity of $C_{\text{hybrid}} = 100 \pm 25$ at room temperature. Additionally, we incorporated a new high-finesse fiber cavity ($\mathcal{F} = 785$), significantly enhancing the coupling strength and achieving $C_{\text{hybrid}} = 5900 \pm 1300$ at room temperature. Further increasing the cavity finesse to $\mathcal{F} = 14500$ did not yield improvements in coupling strength, aligning with theoretical predictions.

Q 48.6 Wed 17:00 Tent

**Remote sensing using an auxiliary quantum system** — •Manuel Bojer[1], Jörg Evers[2], and Joachim von Zanthier[1] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Quantum Optics and Quantum Information, Staudtstr. 1, 91058 Erlangen, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

A key goal in the recently fast developing field of quantum sensing is the extraction of information about physical quantities with high precision using quantum features. Many different platforms or realisations of quantum sensors exist. A particular branch focuses on sensing tasks assisted by auxiliary systems, which aid for overcoming classical precision limits. In this work, we use the combined signal of a system of interest and a remote system, entangled with each other via measurements, to extract information that is otherwise difficult to access. The entire system consists of three identical atoms, where two atoms, representing the system of interest, are assumed to be close to each other such that they interact via the dipole-dipole interaction while the third atom is located at a distance $d \gg \lambda$ (with $\lambda$ the atomic transition wavelength). Although the distant third atom does not directly interact with the collective two-atom subsystem, it can be used to alter the total systems emission properties via measurement-induced entanglement. We present different detection schemes employing Glauber's third-order photon correlation function to extract important parameters such as the separation $d$ (with potentially $d \ll \lambda$) or the initial state of the two-atom subsystem.

Q 48.7 Wed 17:00 Tent

**Identifying error sources of dipole-dipole coupling mediated two-qubit gates between NV-centers in diamond** — •Florian Ferlemann[1,3], Timo Joas[2], Roberto Sailer[2], Philipp Vetter[2], Genko Genov[2], Fedor Jelezko[2,4], Ressa Said[2], Tommaso Calarco[1,3,5], and Matthias Müller[1] — [1]Peter Grünberg Institute - Quantum Control (PGI-8), Forschungszentrum Jülich GmbH, 52428 Jülich, Germany — [2]Institute for Quantum Optics, Ulm University, 89081 Ulm, Germany — [3]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [4]Center for Integrated Quantum Science and Technology (IQST), Ulm University, 89081 Ulm, Germany — [5]Dipartimento di Fisica e Astronomia, Università di Bologna, 40127 Bologna, Italy

To create a large spin register in diamond realizing a good entangling gate between NV centers can be crucial. Even though entanglement between a pair of NV centers has been observed, high two qubit gate fidelities have not yet been demonstrated. We investigate at which conditions the latter can be realized with a pair of NV centers at room temperature, taking into account that their axes are misaligned and the nuclear spins are non-initialized. We analyze the behavior of the gate errors under different Rabi frequencies and identify the error sources that limit the single-qubit and two-qubit gate fidelities, where we explicitly study the influence of the nitrogen nuclear spins on the two-qubit gates under dynamical decoupling sequences. In this context we demonstrate high two-qubit gate fidelities.

Q 48.8 Wed 17:00 Tent

**Pure single-photon generation using pulsed SPDC in a monolithic cavity** — •Xavier Barcons Planas[1,2], Helen M. Chrzanowski[2], Leon Messner[2], and Janik Wolters[2,3] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Institute of Optical Sensor Systems, German Aerospace Center, Berlin, Germany — [3]Institut für Optik und Atomare Physik, Technische Universität Berlin, Berlin, Germany

Entangled states of multiple photons are essential for advancing the capabilities of photonic quantum technologies. The generation of large multi-photon entangled states requires light sources that provide highly pure photons with high efficiency (either deterministic or heralded), as these factors limit scalability. A common method is to herald single photons from photon-pair sources based on spontaneous parametric down-conversion (SPDC). While the multimode spatial and spectral nature of SPDC emission can constrain the heralding efficiency and purity, engineering techniques such as waveguide geometries [1], group velocity matching [2], and cavity resonators [3] can refine the output to exhibit single-mode behaviour. Here, we present a narrowband (170 MHz) single-photon source at the C-band based on pulsed SPDC in a monolithic crystal cavity. Pure and fiber-compatible single photons have been generated with 85% heralding efficiency.

[1] A. Christ *et al.*, Phys. Rev. A **80**, 033829 (2009)
[2] P. J. Mosley *et al.*, Phys. Rev. Lett. **100**, 133601 (2008)
[3] R. Mottola *et al.*, Opt. Express **28**, 3159 (2020)

Q 48.9 Wed 17:00 Tent

**Click boson sampling** — •Sitotaw Eshete, Torsten Meier, Polina Sharapova, and Jan Sperling — Paderborn University, Paderborn, Germany

Linear optical networks are essential building blocks for developing commercially accessible quantum technologies. Our work's primary objective is to approximate the permanent computation in boson sampling using cutting-edge click detection systems, which are used for both input state and network-output detection. Each input mode's click detectors herald multiphoton states, which are produced by parametric down-conversion sources. Then, the output click-counting distribution can be expressed as a linear combination of determinants of certain coefficient matrices that are based on the unitary network matrix together with additional parameters that are pertinent to the detection system. To get close to the precise value of the desired permanent, an exponentially growing number of these determinants must be calculated.

Q 48.10 Wed 17:00 Tent

**3D printed microstructures for scalable coupling of SNSPDS on wafers** — •Stefan Vorwerk[1], Johanna Biendl[1,2], Frederik Thiele[1,2], and Tim Bartley[1,2] — [1]Department of Physics, Paderborn University — [2]Institute for Photonic Quantum Systems

Due to their outstanding properties, such as a broad spectrum, low dark count rates, and high efficiency, SNSPDs have become the leading technology for single-photon detection. For achieving near unity detection efficiency with SNSPDs, low-loss coupling from the fiber to the detector must be ensured. For single-pixel devices, this is readily achieved using self-aligning zirconia sleeves. Nevertheless, this requires a deep-etch into the substrate, which may be detrimental or impossible in some substrates, and limits the packing density of detectors. We are exploring alignment techniques on arbitrarty substrates and wafers. To enhance coupling efficiency, we fabricate 3D printed nanostructures using 2-photon polymerization to align the fiber with the detector and provide mechanical stability. It is also possible to integrate additional optics, such as lenses or tapers, into the 3D printed structure. For an optimized fabrication process and the characterization of the printed structures, we investigate the optical properties and the mechanical stability of the polymer at cryogenic temperatures and test different coupler designs.

Q 48.11 Wed 17:00 Tent

**Increasing the Efficiency of Microwave Coupling to NV Centers from Microstrip Transmission Lines** — •Dennis Stiegekötter[1], Jens Pogorzelski[1], Ludwig Horsthemke[1], Frederik Hoffmann[1], Ann-Sophie Bülter[1], Markus Gregor[2], and Peter Glösekötter[1] — [1]FH Münster, Department of Electrical Engineering and Computer Science, Steinfurt, Germany — [2]FH Münster, Department of Engineering Physics, Steinfurt, Germany

Quantum technologies often rely on microwaves to excite electron spin state transitions. In the application of, e.g., magnetic field sensors or mobile experiment kits [1], a high MW intensity is needed and results in bulky signal sources. The required power of the source can be reduced by an optimal coupling and high return loss of the transmission line to the MW antenna close to the diamond sample. This study focuses on an efficient change of the electron spin state in nitrogen-vacancy (NV) centers in diamond using microstrip line structures. To enhance the effectiveness of this excitation, we aim to increase MW field intensity by optimizing the substrate thickness and adjusting the current density within the microstrip line. The challenge with the identified microstrip line is its deviation from the 50 $\Omega$ waveguide impedance, leading to microwave reflections. To circumvent this issue, a three-stage quarter-wave transformer is utilized, ensuring broadband matching to a 50 $\Omega$ network and minimizing reflection losses. [1] Stegemann, J.*et al.*Modular low-cost 3D printed setup for experiments with NV centers in diamond.*European Journal of Physics*44, 035402 (2023).

Q 48.12 Wed 17:00 Tent

**Dynamics of optically levitated nanoparticle arrays** — •Artur Bichs[1], Uroš Delić[2], and Benjamin A. Stickler[1] — [1]Institute for Complex Quantum Systems, Ulm University — [2]Vienna Center for Quantum Science and Technology, University of Vienna,

Optically levitated nanoparticles offer a promising platform for high-precision sensing and for exploring quantum physics with massive objects. Here, we study the dynamics of tweezer-levitated nanoparticles coupled via optical binding and via coherent scattering into a common cavity mode. We derive the corresponding quantum master equation for the joint nanoparticle array-cavity dynamics, study the linearized dynamics for two and three particles, and discuss implications for sensing and entanglement observations.

Q 48.13 Wed 17:00 Tent

**Developing a database for UHV and XUHV suitable materials for use in quantum technologies** — •Vanessa Galbierz[1], Pascal Engelhardt[1,2], Simone Callegari[1,3], Constantin Nauk[1,2], Benjamin Kraus[1], and Piet Schmidt[1,2] — [1]Physikalisch Technische Bundesanstalt, 38116 Braunschweig, Germany — [2]Leibniz University Hannover, 30167 Hannover, Germany — [3]currently with: VAT Vakuumventile AG, 9469 Haag, Switzerland

The lifetime and coherence time of atomic quantum systems is often limited by the achievable vacuum background gas pressure. Room-temperature vacuum systems reaching 10e-11 mbar can be easily built using mostly standard, off-the-shelf parts. However, this typically changes when the system is equipped with all components for a working in-vacuum experiment, such as ion-based optical clocks and quantum computers. Introduced materials can severely limit the achievable pressure. In addition, the outgassing behavior of new types of materials and parts produced with innovative methods, such as additive manufacturing, is often not yet known. We present a strategy to identify, measure and classify potentially suitable materials and their outgassing behavior to assess their suitability for use in UHV and XUHV. In this context, we introduce our two vacuum test benches, explain the measurement and evaluation methods used and show the first results of an emerging material database, which aims to provide standardized outgassing data for materials of different categories.

Q 48.14 Wed 17:00 Tent

**SPDC photon pair source for Quantum Random Walk Application on an integrated quantum photonic processor** — •Christoph Engelberg, Jonas Philipps, Evelyn Kimmerle, and Florian Elsen — Chair for Laser Technology, RWTH Aachen University

Photonic quantum computing (PQC) is emerging as a promising approach to quantum computing due to photons' near-decoherence-free nature, room temperature operation and high-precision manipulation. One crucial component for PQC are quantum light sources, which can be realized by spontaneous parametric down-conversion (SPDC) photon pair sources. A key requirement for such sources is a high indistinguishability of the photons.

In this work, an SPDC photon pair source at telecom wavelength is set up and characterized with an on-chip integrated quantum photonic processor (QPP). Furthermore, its practical suitability and performance for a potential use in the field of PQC is confirmed. By further performing spectral filtering, a Hong-Ou-Mandel (HOM) interference visibility of 98.41% was achieved. A high indistinguishability of the photons is thereby shown.

A possible PQC application are quantum random walks (QRWs) on a QPP, where a pair of indistinguishable photons is passed through a linear optical network. In a future step, this photon pair source will be used to experimentally and simulatively investigate the influence of the source properties on the performance of QRWs.

Q 48.15 Wed 17:00 Tent

**Efficient Method for Selectively Loading Dielectric Nanoparticles onto Optical Tweezers in a Vacuum** — •Luana Rubino[1,2], Zijie Sheng[1,2], Seyed Khalil Alavi[1,2], Moosung Lee[1,2], and Sungkun Hong[1,2] — [1]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Stuttgart, DE — [2]Center for Integrated Quantum Science and Technology (IQST), University of Stuttgart, Stuttgart, DE

Quantum levitodynamics is the field of research that studies the quantum motion of mesoscopic objects levitated, e.g., in optical tweezers. In this field, the so-called spraying method is conventionally used to load the particle to an optical trap stochastically, limiting the efficiency and selectivity of the trapping. To address this, we are developing an efficient method for selectively loading nanoparticles into an optical tweezer. This approach involves first selectively imaging the particles on a surface and then loading them into an optical tweezer, enabling the trapping only the particle of interest. The loading process is achieved through vibration-induced acceleration, which allows particles to be efficiently shoot into the tweezer. We present our recent progress toward achieving this goal.

Q 48.16 Wed 17:00 Tent

**Evolution of correlations in superfluorescent bursts** — •Yoan Spahn, Thomas Halfmann, and Thorsten Peters — Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstraße 6, 64289 Darmstadt, Germany

We experimentally study correlations in superfluorescent bursts emitted by a dilute, disordered ensemble of atoms inside a hollow-core fiber. Starting from an initially inverted effective two-level system, we measure the temporal evolution of the second-order coherence function of the light emitted into the waveguide mode. By varying the number of atoms as well as the decay rate, we are able to study correlations below and above threshold to collective emission. Tuning our system from individual to collective emission in the regime of multiple optical bursts, we observe a clear evolution of correlations between consecutive bursts.

Q 48.17 Wed 17:00 Tent

**Design of a decorrelated PDC source at telecom wavelenghts in TFLN waveguides** — •Ernst-Lukas Kuhlmann, Silia Babel, Laura Bollmers, Werner Ridder, Christian Golla, Sebastian Lengeling, Christof Eigner, Laura Padberg, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098, Paderborn, Germany

Integrated quantum optics plays a key role in communication and computation and its most fundamental building block are single photons. A promising material platform for photonics in this field is thin-film lithium niobate (TFLN). While integrated optics in conventional lithium niobate profit from its wide transparency window and high nonlinearity, its application in a thin-film configuration additionally encompasses the potential for high conversion efficiencies due to large mode confinement. Therefore, TFLN is an excellent platform for the integration of photon pair sources. Here, we explore the use of periodically poled, MgO-doped TFLN for decorrelated type II parametric down-conversion(PDC) single photon telecom C band wavelength sources with a 0-degree phase matching angle. This offers the advantage to create pure signal photons in arbitrary temporal shapes. We examine the necessary geometry parameters for such a PDC source and the influence of these parameters on the spectral shape. Moreover, we discuss possibilities to reconstruct it with adaptive poling or by tapering the waveguide width. With this work, we aim to contribute to the development of more efficient and accessible quantum light sources.

Q 48.18 Wed 17:00 Tent

**Mølmer-Sørensen Gates Robust to AC Shifts** — •Erin Feldkemper — Institut für theoretische Physik, Leibniz Universität Hannover

In the past years the implementation of quantum gates has increased significantly. With the growing interest on fast and high-fidelity quantum gates, the interest in the optimization of these has grown as well. One of the key challenges is mitigating the AC Stark or Zeeman shift, which can arise in both laser-driven and microwave-driven gates, introducing errors which degrade the performance.

In this work, we focus on microwave-driven Mølmer-Sørensen gates and use the Magnus expansion in order to analyze the impact of the AC Zeeman shift on the gate performance. Starting from the full system Hamiltonian, we derived an effective Hamiltonian which includes the leading-order corrections induced by the AC Zeeman shift. This effective model was used for numerical simulations in order to validate the approximations made in the derivations and to gain insights into the gate*s fidelity and coherence properties. Here Kraus operators were implemented for the evaluation of the fidelity, while the von Neumann entropy was used to quantify entanglement and coherence degradation.

The control parameters can be optimized based on a cost function derived from the Magnus expansion. This optimization aims to further reduce the impact of the AC Zeeman shift and enhance gate fidelity.

Q 48.19 Wed 17:00 Tent

**Zerovak: Compact and portable vacuum and laser system technology for cold atom experiments** — •Nora Bidzinski[1], Bojan Hansen[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, 22761 Hamburg, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

Performing ultra cold atom experiments outside a laboratory environment such as mobile platforms or space applications requires a compact and energy-efficient experimental setup.

Hence, we present a novel flange-free ultra-portable vacuum chamber without the necessity of an active getter pump. Choosing Zerodur, a glass ceramic with low helium and hydrogen permeability as well as very low thermal expansion coefficient, ensures maximum stability against thermal fluctuations due to environmental changes.

Further, we propose a compact and highly miniaturised laser system for cooling atoms including a method for substituting AOMs while maintaining full functionality.

Q 48.20 Wed 17:00 Tent

**Towards standardized characterization of ion traps for industry and research** — •Martin Hesse[1,3], Jan Kiethe[1], André Kulosa[1], Max Glantschnig[1,2,3], Christian Flasch[1,2,3], Nicolas Spethmann[1], and Martin Hesse[1,3] — [1]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [2]Infineon Technologies Austria AG, Villach, Austria — [3]Leibniz Universität Hannover, Hannover, Germany

Ion traps have evolved to be a mature technology for applications in quantum sensing and quantum computing. As this technology transforms from research objects into industrial applications, manufacturers require standardized comparisons of their quantum technology (QT) components to maintain worldwide competitiveness and strengthen their industrial development cycles. Here, the Quantum Technology Competence Center (QTZ) at PTB serves as a national hub to support German industry partners in the evaluation of their QT components.

Being one of the pillars of the QTZ, the user facility *Ion traps* offers an experimental testbed for the characterization of ion traps from academia and industry. This setup provides fully automated experiment control enabling user friendly operation for standardized measurement routines. As part of the European *Qu-Test* project we developed a data sheet for the characterization of ion traps in collaboration with Infineon Technologies Austria AG. This document summarizes the specifications of the ion traps under test for industry requirements and serves as a suggestion towards standardized benchmarking of ion traps.

Q 48.21 Wed 17:00 Tent

**Prototype Cell Design for NV Based Current Monitoring of Zinc-Air Batteries** — •Ghulam Raza[1], Juan Manuel Alvarez Cisneros[1], Jonas Homrighausen[1], Jan-Ole Thranow[2], Felix Winters[2], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Muenster. — [2]Department of Electrical Engineering and Computer Science, FH Muenster.

Zinc-air batteries are an attractive energy storage technology due to their high energy density, environmental friendliness, and cost-effectiveness. They are based on electrochemical reactions between zinc and oxygen from air offering a promising alternative to lithium-ion batteries. The addition of quantum sensors enable huge potential in monitoring internal dynamics of these batteries.

In this work we present a possible zinc-air battery cell design suitable for quantum sensors based on microdiamonds containing NV centers.The cell includes a zinc anode, nickel and gas discharge sheets for charging and discharging, and a KOH aqueous electrolyte. Additionally, it features an optical access to monitor the cell dynamics.

Q 48.22 Wed 17:00 Tent

**Simultaneous Three Component Magnetometry Using NV Centers for Applications in Power Distribution Networks** — •Frederik Hoffmann[1], Ann-Sophie Bülter[1], Ludwig Horsthemke[1], Jens Pogorzelski[1], Markus Gregor[2], and Peter Glösekötter[1] — [1]Dept. Electrical Engineering and Computer Science, FH Münster — [2]Dept. Engineering Physics, FH Münster

This poster presents a concept for current measurement in low and medium voltage power distribution networks. For current measurement, the concentric magnetic field around the current-carrying conductor can be measured using a nitrogen-vacancy quantum magnetic field sensor [1]. A bottleneck in current measurement systems is the readout electronics, which is usually based on optically detected magnetic resonance (ODMR) [2]. A new concept is presented here that tracks up to four resonances simultaneously for the detection of the three axis magnetic field components and the temperature. The electronics is based on FPGA (Red Pitaya). For this purpose, a plug-on board has been developed that allows to control the excitation laser, the generation of the microwaves, interfacing the photodiode and provides additional fast digital outputs.

[1] Pogorzelski, J., Horsthemke, L., Homrighausen, J., Stiegekötter, D., Gregor, M., & Glösekötter, P. (2024). Compact and Fully Integrated LED Quantum Sensor Based on NV Centers in Diamond. Sensors, 24(3), 743. [2] Schloss, J., Barry, J., Turner, M., & Walsworth, R. (2018). Simultaneous Broadband Vector Magnetometry Using Solid-State Spins. Phys. Rev. Appl., 10, 034044.

Q 48.23 Wed 17:00 Tent

**An economic cryostat for quantum optical experiments** — •Max Masuhr, Hazem Hajjar, Bo Deng, Babak Behjati, Kathrin Schumacher, and Daqing Wang — Institut für Angewandte Physik, Universität Bonn, Bonn, Germany

Many quantum optical experiments are susceptible to vibrations caused by the helium compression cycle in the cryostat, necessitating delicate vibration isolation designs. Here, we present the mechanical and electrical construction of a low-cost custom cryostat built around a commercial cold head that mitigates vibrations while allowing full access for quantum optical experiments. The cryostat houses a sample space, which includes a high-numerical-aperture lens for imaging single organic dye molecules. Utilizing the tandem displacement of the sample and the objective, vibrational effects on measured optical images are reduced. The design of this cryostat could be interesting for an extended range of quantum optical experiments on solid-state samples.

Q 48.24 Wed 17:00 Tent

**Feedback cooling of levitated nanoparticles based on single photon detection** — •Luis Kunkel Garcia, Henning Rudolph, and Klaus Hornberger — University of Duisburg-Essen, Faculty of Physics, Lotharstraße 1, 47057 Duisburg, Germany

Recent experiments demonstrate groundstate cooling of optically levitated nanoparticles by combining efficient homodyne detection of the scattered light with feedback [1,2]. Here, we theoretically analyze a scheme to optimally cool smaller nanoparticles into the quantum regime, provided that only single photon detection events of the scattered light intensity are available. The measurement rate then depends only on the square of the particle coordinate. This requires a Bayesian analysis of the entire history of the photon counts, in combination with a stochastic choice of the feedback force. We estimate the attainable temperature under realistic assumptions concerning the detection efficiency and dark count rates.

[1] Magrini et al., Real-time optimal quantum control of mechanical motion at room temperature. Nature 595, 373 (2021)

[2] Tebbenjohanns et al., Quantum control of a nanoparticle optically levitated in cryogenic free space. Nature 595, 378 (2021)

Q 48.25 Wed 17:00 Tent

**Investigation of the role of pump noise on the generation of nonclassical light from optical parametric oscillators** — •Sopio Bregadze, Roger A. Kögler, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489, Berlin, Germany

Photonic quantum technologies rely on nonclassical states of light, such as squeezed and Fock states. Optical parametric oscillators (OPOs) are widely used for the generation of such states, leveraging enhanced light-matter nonlinear interactions through optical feedback. A typical configuration consists of a bulk nonlinear medium place inside an optical cavity. In order to determine the OPO output state, the dynamics of an open quantum system must be analysed. Here, we numerically solve the equations of motion derived from a master equation formalism, and calculate the state covariance matrix. We present results for OPOs based on degenerated parametric down conversion operating below oscillation threshold. The impact of excess pump noise on the generated states is investigated, with focus on their squeezing levels and purity. The obtained results are compared with current experimental devices dedicated for the generation of single-mode vacuum squeezed states.

Q 48.26 Wed 17:00 Tent

**Fiber-Cavity Enhanced Photon Emission from Defect Centers in hBN** — •Manuel Stetter, Patrick Maier, and Alexander Kubanek — Institute for Quantum Optics, University Ulm, Germany

Realization of quantum photonic devices requires coupling single quantum emitters to the mode of optical resonators. We present a hybrid system consisting of a defect center in a hexagonal boron nitride (hBN) nanoparticle and a fiber-based Fabry Pérot cavity. Signal enhancement and strongly narrowed linewidths are achieved, which is owing to cavity funneling.

Q 48.27 Wed 17:00 Tent

**Cavity enhanced free-electron-photon coupling in the recoil regime** — •Nils Bode[1], Zhexin Zhao[1], Julian Litzel[1], Tomáš Chlouba[2], Manuel Konrad[1], and Peter Hommelhoff[1,3] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Center for Nanophotonics, NWO-Institute AMOLF, 1098 XG Amsterdam — [3]Department Physik, Ludwig-Maximilians-Universität München (LMU), 80799 München

The fundamental role of integrated photonics in the recent advances of optical communication, biomedical applications, sensors, spectroscopy and quantum technologies has proven its versatility in various fields. Leveraging the possibilities of regular and metamaterial optical waveguide technology, we present simulations of the quantum interaction of low energy free electrons with cavity photons designed for the recoil regime. This regime is of special interest as the effects associated with the electron's recoil allow the construction of novel photonic states like deterministic single photon states, Greenberger-Horne-Zeilinger (GHZ) states, NOON states, squeezed vacuum, twin beams and many more. We further provide theoretical upper bounds for the free-electron-photon coupling for different materials and electron energies at various impact parameters. These upper bounds can be used to put the performance of simulated structures into perspective and validate the feasibility of proposed state construction schemes.

Q 48.28 Wed 17:00 Tent

**Exploiting NV Center Spin Dynamics for Low-Temperature All-Optical Thermometry** — •Jonas Homrighausen[1], Matthias Hollmann[1], Ludwig Horsthemke[2], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster — [2]Department of Electrical Engineering and Computer Science, FH Münster

The nitrogen vacancy center in diamond has been established as a promising tool to conduct temperature measurements down to the nanoscale for biomedical applications, microelectronics and material analysis. The protocols typically rely on either the spin-dependent fluorescence of the NV quantum system, manipulated by microwave frequencies [1], or the prominence of the zero-phonon line in the fluorescence spectrum [2]. The latter, all-optical approach however is sensitive to fluctuations in the fluorescence intensity and relies on spectral analysis, increasing the complexity.

Here, we explore an all-optical approach that avoids microwave-based spin manipulation and reduces susceptibility to intensity fluctuations. This method exploits the temperature dependent spin dynamics of the NV ground state in bulk material. We assess sensor performance as a temperature probe and discuss the sensitivity of this method. These advancements promise robust and reliable temperature measurements in harsh environments and offer seamless integration into all-optical NV magnetometers.

[1] Fujiwara, M. *et al. Sci. Adv.* **6**, eaba9636 (2020).
[2] Fukami, M. *et al. Phys. Rev. Appl.* **12**, 014042 (2019).

Q 48.29 Wed 17:00 Tent

**Towards video-rate vector magnetometry based on polarimetric optically detected magnetic resonance** — •Tofianme Sorgwe[1], Philipp Reuschel[1], Florian Sledz[1], Mario Agio[1,2], and Assegid Flatae[1] — [1]Laboratory of Nano-Optics, University of Siegen, 57072 Siegen, Germany — [2]National Institute of Optics (INO), National Research Council (CNR), 50019 Sesto Fiorentino, Italy

Vector magnetometry has various applications in navigation systems, precision metrology, and life sciences. Recently, optically detected magnetic resonances (ODMR) based on negatively charged nitrogen-vacancy ($NV^-$) color centers in diamond have been developed as a platform for magnetic sensing. However, most approaches require knowledge of the crystal axes and need an external magnetic bias field to measure the field's orientation or they rely on the use of single $NV^-$ centers and require volumetric data sets. Here, we show vector magnetometry based on polarometric ODMR on ensembles of $NV^-$ color centers without bias field [1]. By avoiding the complex dataset, we will be able to reach fast data acquisition, with implications for video-rate vector magnetometry.

[1] Philipp Reuschel, Mario Agio, and Assegid M. Flatae. Vector magnetometry based on polarimetric resonance. Advanced Quantum Technologies, 5 2022000777 (2022).

Q 48.30 Wed 17:00 Tent

**Quantum interference in a Ti:LiNbO3 waveguide device as a tool for spectral shaping** — •Jonas Babai-Hemati, Kai Hong Luo, Patrick Folge, Sebastian Lengeling, Philipp Mues, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

By exploiting optical interference, breakthroughs in research and metrology could be achieved. Traditional interferometers rely only on classical linear optical components, and therefore cannot benefit from quantum nature of light. Interferometers based on nonlinear optical components can utilize this potential by interference of quantum processes. This can lead to improved metrology properties and opens new possibilities in quantum state engineering. However, a free-space-based interferometer setup comes with challenges in stability and lacks scalability. To investigate the capability in state engineering of a fully integrated quantum interferometer, we fabricated an SU(1,1) like Ti:LiNbO3 waveguide based quantum interferometer device. The single waveguide structure is composed of two parametric down-conversion (PDC) sections separated by phase shifters (PS) and polarization converters (PC). With these modulators, the spectral shape of the quantum state resulting from the PDC-PDC interferences can be actively tailored. By theoretical and experimental study of this device, we explore the frame of tailorable states.

Q 48.31 Wed 17:00 Tent

**Desorption-induced decoherence of nanoparticle motion** — •Jonas Schäfer[1], Benjamin A. Stickler[2], and Klaus Hornberger[1] — [1]Faculty of Physics, University of Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany — [2]Institute for Complex Quantum Systems, Ulm University - Albert-Einstein-Allee 11, D-89069 Ulm, Germany

Levitated nanoparticles are well suited for sensing applications and fundamental tests of quantum theory [1,2]. Their center-of-mass motion can be prepared in the ground state [1] and future experiments will probe the quantum regime of their rotation dynamics [3]. Motivated by these experimental advances, we present the master equation describing the impact of desorption on their ro-translational quantum state. The Lindblad operators, which can be related to the local flux of desorbates from the particle surface, account for both the momentum and angular momentum kicks, as well as for the information contained in the anisotropy of the desorbate flux. For well localized states the dynamics can be characterized by a matrix of diffusion tensors (and a photophoretic force), known from classical treatments [4].

[1] Gonzalez-Ballestero, Aspelmeyer, Novotny, Quidant, and Romero-Isart, Science 374, eabg3027 (2021)
[2] Stickler, Hornberger, and Kim, Nat. Rev. Phys. 3, 589-597 (2021)
[3] Gao, van der Laan, Zielińska, Militaru, Novotny and Frimmer, PRR 6, 033009 (2024)
[4] Martinetz, Hornberger, and Stickler, PRE 97, 052112 (2018)

Q 48.32 Wed 17:00 Tent

**Robust and miniaturized Zerodur based vacuum systems for quantum sensing applications** — •David Latorre Bastidas[1], Sören Boles-Herresthal[1], Nora Bidzinski[2], Bojan Hansen[2], André Wenzlawski[1], Ortwin Hellmig[2], Klaus Sengstock[2], and Patrick Windpassinger[1] — [1]Institute of Physics, Johannes Gutenberg University Mainz — [2]Institute for Quantum Physics, Universität Hamburg

In recent years, quantum sensing technologies based on cold atoms have been proposed to solve existing problems in science and industry. To enhance the accessibility and robustness of these systems, we propose using Zerodur in the vacuum system. Zerodur is a glass ceramic with a negligible coefficient of thermal expansion (CTE), high mechanical strength, and low helium permeability, making it an ideal candidate for vacuum chambers. Its non-magnetizable and non-conductive properties allow for embedded wire structures within the vacuum chamber walls, enabling the generation of arbitrary 3D magnetic fields with high quality and minimal disturbances for atom cooling and trapping.

This poster focuses on the development of a passively pumped, stand-alone Zerodur vacuum chamber for quantum sensing applications, with an initial objective of demonstrating a MOT in a compact, shoebox-sized system. The chamber integrates non-evaporable getters and alkali metal dispensers activated by UV light. This system approach sets the foundation for future compact quantum sensors, offering significant potential for practical, real-world applications.

Q 48.33 Wed 17:00 Tent

**Realization of adaptive poling in thin-film lithium niobate waveguides** — •Tobias Babai-Hemati, Laura Bollmers, Michael Rüsing, Laura Padberg, and Christine Silberhorn — University of Paderborn, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn

Quantum technologies rely on internal quantum networks. As a result, all components- such as storage, fiber, and sensors- require frequency converters to handle the differences in frequencies.

In this work, the chosen platform is thin-film lithium niobate (TFLN). It has large nonlinear properties and a high effective refractive index contrast with $SiO_2$. In TFLN, we realize frequency conversion with quasi-phase matching which is the periodic inversion of the crystal structure using an electric field. However, phase matching in TFLN waveguides is highly sensitive to variations in thin-film thickness of lithium niobate. We present a realization of adaptive poling (locally adapted periods) in TFLN to compensate for this effect. First, we measured the thin-film thickness profiles of a MgO-doped TFLN sample. Then, we simulated the corresponding poling periods, fabricated the devices, and poled with an electric field.

The poling results show that slight changes in the poling period do not significantly affect the homogeneity of the poled area with a single voltage pulse. In conclusion, this could allow for more efficient on-chip frequency conversions.

Q 48.34 Wed 17:00 Tent

**Loss Analysis of a Massively Multiplexed Superconducting Nanowire Photon-Number-Resolving Detector** — •Isabell Mischke[1], Timon Schapeler[1,2], Fabian Schlue[2,3], Michael Stefszky[2,3], Benjamin Brecht[2,3], Christine Silberhorn[2,3], and Tim J. Bartley[1,2] — [1]Department of Physics, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany — [2]Institute for Photonic Quantum Systems (PhoQS), Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany — [3]Integrated Quantum Optics, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany

Intrinsic photon-number resolution (PNR) has been shown by analyzing the rising edge of superconducting nanowire single-photon detector (SNSPD) electrical signals, which leads to easy accessibility of photon-number resolved measurements. Nevertheless, the overlap of the underlying distributions for different photon numbers limits the number of resolvable photons per SNSPD up to a few photons. Our work scales PNR up to thousands of photons by combining the intrinsic PNR of SNSPDs with temporal and spatial multiplexing. Specifically, we use eight spatial bins with 128 temporal bins each, for a total of 1024 bins. Each bin can resolve up to at least five photons. With detailed data analysis, the losses per bin can be calculated to determine the efficiency of the system and to increase the understanding of its behavior. This knowledge will enable further investigations of the multiplexing system in the future.

Q 48.35 Wed 17:00 Tent

**Using a Microfabrication Platform for Direct Laser Writing of NV-Centers and Optical Interfacing on Diamond** — •Marina Peters[1], Jonas Homrighausen[1], Ghulam Raza[1], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster — [2]Department of Electrical Engineering and Computer Science, FH Münster

Nitrogen-vacancy (NV) centers in diamond have proven to be an important resource for applications such as quantum computing and quantum sensing. The precise, deterministic placement of NV centers and their reliable optical coupling is of particular importance. Direct laser writing (DLW) of NV centers in diamond enables high spatial placement control with minimal damage to the lattice [1].

Here we investigate the potential of fabricating NV centers by femtosecond laser pulse treatment using a commercially available microfabrication platform. This offers the opportunity to integrate multiple fabrication processes into a single workflow: precise surface marking for alignment and referencing, the generation of a pattern of NV centers within the diamond lattice, and the fabrication of micro-optical components such as microlenses and waveguides on the diamond substrate for efficient fluorescence extraction and packaging.[2] This approach has the potential to simplify the production and improve the scalability of highly integrated diamond-based quantum devices.

[1] Chen, Y.-C. et al. Optica 6, 662667 (2019). [2] Bogucki, A. et al. Light Sci. Appl. 9, 48 (2020).

Q 48.36 Wed 17:00 Tent

**Manufacture high-finesse fiber Fabry-Perot cavities for quantum information processing** — •Johannes Berger[1], Matthias Michalek[1], Constantin Grave[1], Isabelle Safa[1], Marvin Holten[1], and Julian Leonard[1,2] — [1]TU Wien, Atominstitut, Vienna Center for Quantum Science and Technology (VCQ), Vienna, Austria — [2]Institute of Science and Technology Austria (ISTA), Am Campus 1, 3400 Klosterneuburg, Austria

Fiber Fabry-Perot cavities (FFPCs) are integral to numerous scientific and technological applications, such as cavity quantum electrodynamics experiments, tunable optical filters, cavity-based spectroscopy of gases and many more. Our team has established an advanced, automated fabrication system for creating curved mirrors on the endfacets of optical fibers. The curvature is precisely formed with a CO2 laser, while the reflective coating is applied externally. By using an acousto-optic modulator (AOM), the beam pulse can be manipulated as required to improve the desired fiber ablation. In our setup, white light interferometry is incorporated to monitor and measure the created profile throughout the production process, allowing for iterative optimization. This approach aims to produce high finesse cavities, which are essential for many quantum simulation setups like the currently build setup of our group, that uses an tweezer-loaded array of neutral atoms inside a FFPC.

Q 48.37 Wed 17:00 Tent

**Design and characterization of a laser system for airborne gravimetry** — •Alisa Ukhanova[1], Julia Pahl[1], Markus Krutzik[1,2], and the AeroQGrav team[1,3,4,5,6,7,8,9] — [1]Humboldt-Universität zu Berlin, Institut für Physik — [2]Ferdinand-Braun-Institut (FBH), Leibniz-Institut für Höchstfrequenztechnik, Berlin — [3]LUH, Hannover — [4]DLR, Hannover — [5]TUB, Braunschweig — [6]BKG, Leipzig — [7]TUC, Clausthal — [8]Geo++ GmbH, Garbsen — [9]iMAR Navigation GmbH, Ingbert

The *AeroQGrav* project strives to demonstrate a long-term stable air-born gravimeter, with a higher spatial and temporal resolution and a better long-term stability compared to the existing commercial solutions.

We develop the compact and robust modular flight laser system. Three modules will provide the light fields for laser cooling of 87Rb atoms in 2D- and 3D-magneto optical traps, Raman interferometry, and state detection during the flight. This poster explains our design and assembly, presents results of characterization and outlines requirements caused by the aircraft conditions.

This project is supported by the VDI Technologiezentrum GmbH with funds provided by the Federal Ministry of Education and Research (BMBF) under grant number 13N16518.

Q 48.38 Wed 17:00 Tent

**Industrial clock laser system for quantum applications with fractional frequency instability below 6E-16 at 1 s** — •Dewni Pathegama, Filippo Bregolin, and Florian Schäfer — TOPTICA Photonics AG, Lochhamer Schlag 19, 82166, Graefelfing (Munich), Germany

In recent years, there has been an increasing demand for industries to provide compact laser systems with robust design and minimal operational oversight. For quantum computing and optical clocks, coherence times of up to one second are required, corresponding to a fractional frequency instability below 2E-15 for averaging times between 0.1 s and 100 s.

Here we present the latest results from TOPTICA transportable, rack mounted ultra-stable clock laser system. We confirm that our laser system meets these criteria by comparing it against two reference lasers via an optical frequency comb and a frequency counter. We measure an absolute fractional frequency instability of 6E-16 between 0.1 s and 10 s averaging time (modified Allan deviation, lambda counting, 10 ms gate time), and a linear drift of $< 150$ mHz/s over two days. For averaging times below 10 ms (shorter than the minimum gate time of the counter), we use delayed self-heterodyne method.

To understand the physical limits of the system, we characterise the effect of seismic and acoustic vibrations, optical power fluctuations, and fiber noise on the instability. In conclusion, we confirm that our clock laser system is a suitable system for quantum applications in the field that is reliably reproducible.

Q 48.39 Wed 17:00 Tent

**Higher-order photon correlations with trapped ion crystals** — •Zyad Shehata[1], Benjamin Zenz[2], Ansgar Schaefer[2], Maurizio Verde[2], Stefan Richter[1], Joachim von Zanthier[1], and Ferdinand Schmidt-Kaler[2] — [1]Department Physik, FAU Erlangen Nürnberg — [2]QUANTUM, Institut für Physik, JGU mainz

Light scattering from trapped ion crystals displays unexpected photon statistical effects, translating particular geometric arrangements into specific higher-order spatio-temporal photon correlations. Experimentally, background-free coherent scattering on Ca+ ions has been achieved using a two-photon transition via the 32D5/2 metastable state and the narrow quadrupole transition 42S1/2*32D5/2. This process enables spin-selective excitation, allowing far-field imaging of the crystals' spin states via the first-order correlation function g(1). Expanding beyond g(1), we explore higher-order photon correlations that reveals improved imaging as well as super- and sub-radiant phenomena, featuring distinct spatio-temporal emission patterns through entanglement in the ion arrays. We present theoretical predictions as well as detailed calculations on the photon count rates and the signal-to-noise ratios for the m-photon detection events g(m) in particular configurations.

Q 48.40 Wed 17:00 Tent

**Coherent Control of NV Centers Utilizing the Red Pitaya Platform** — •Matthias Hollmann[1], Jonas Homrighausen[1], Naja Livia Bruczyk[1], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster — [2]Department of Electrical Engineering and Computer Science, FH Münster

Nitrogen-vacancy (NV) centers in diamond have emerged as important tools for quantum sensing, with applications ranging from magnetic field to temperature measurements. Achieving high sensitivity in such applications requires precise coherent spin control.However, conventional lab-based setups often rely on bulky, advanced, and costly components, limiting accessibility and scalability. Therefore cost effective and compact sensing platforms are getting more important for research and industry [1]. In this work, we investigate the use of the Red Pitaya platform -a commercial off-the-shelf (COTS), customizable, and cost-effective FPGA platform- as an alternative solution. This versatile hardware enables both signal generation and acquisition necessary for measuring $T_1$ and $T_2$ times in NV centers. The setup demonstrates a promising compact and cost effective alternative to conventional systems, suitable for magnetic and temperature sensing. It paves the way for portable, low-cost solutions in quantum sensing applications and can be adapted for different usecases and measurement environments. [1] Stiegekötter D. et al, Microcontroller-optimized measurement electronics for coherent control applications of NV centers. Sensors 24, 3138 (2024)

Q 48.41 Wed 17:00 Tent

**Recent Advances in Low-Cost 3D Printed Experiment Kits for Quantum Education** — •Leon Sievert[1], Marina Peters[1], Dennis Stiegekötter[2], Jonas Homrighausen[1], Nils Haverkamp[3], Peter Glösekötter[2], Stefan Heusler[3], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster, Germany — [2]Department of Electrical Engineering and Computer Science, FH Münster, Germany — [3]Institute of Physics Education Research, University of Münster

The growing interest in quantum technology in society and industry is met by an increasing demand in quantum education. This results in a need for low-cost, versatile and resilient experimental setups for research and teaching purposes.To approach this challenge, an open innovation platform has been proposed [1,2]. This combines an open-source, 3D printable setup, with low-cost hardware in a modular, tactile cube aesthetic. The freely positionable experiment parts are placed on a reliable grid structure. Experiments to measure optically detected magnetic resonance (ODMR) in microdiamond NV center ensembles[3] are a large use case for this setup. In this work, we present two major advances: A wireless module based on ESP32 was used to simplify the visualization process of sensor data [1]. Additionally, the educational setup was improved for coherent control experiments in NV center ensembles using a low-cost microcontroller setup [4]. [1] www.O3Q.de [2] www.quantumminilabs.de[3] Stegemann, J. et al. European Journal of Physics 44 (2023)[4] Stiegekötter D. et al, Sensors 24, 3138 (2024)

Q 48.42 Wed 17:00 Tent

**Simple Rate Equation Model to Simulate the Fluorescence Lifetime of NV Ensembles in Microdiamond Powder** — •Glen Neiteler[1], Ludwig Horsthemke[2], Naja Livia Burczyk[1], Sarah Kirschke[1], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster University of Applied Sciences, Stegerwaldstr. 39, 48565 Steinfurt, Germany — [2]Department of Electrical Engineering and Computer Science, FH Münster University of Applied Sciences, Stegerwaldstr. 39, 48565 Steinfurt, Germany

In the past few years, the nitrogen-vacancy (NV) center in diamond was the subject of extensive and promising research in the fields of quantum computing, quantum key distribution and quantum sensing. Recently, we experimentally investigated the fluorescence lifetime of the excited state of NV ensembles in microdiamond powder for application in all-optical quantum sensors [1]. To gain insights into the spin dynamics of NV ensembles in microdiamond powder, we simulate the fluorescence lifetime with a simple rate equation model.

[1] Horsthemke, L., et al. Excited-state lifetime of NV centers for all-optical magnetic field sensing. Sensors 24, 2093 (2024).

Q 48.43 Wed 17:00 Tent

**Towards Electrode-integrated Fiber Cavities for Ion Trapping and Quantum Computation** — •Tuncay Ulas, Luca Graf, Lasse Irrgang, and Ralf Riedinger — Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg

Quantum technologies are increasingly capturing the interest of researchers. Trapped-ion systems are a leading platform for quantum computation, offering high-fidelity operations and scalability. We present an ion trap design that integrates optical fiber cavities into the electrode structure. This integration enables precise control of the cavity geometry, enhancing ion-photon coupling and supporting the development of scalable architectures for quantum technologies.

Q 48.44 Wed 17:00 Tent

**Adhesive- Mounted Optics for Relaxometry with NV- centers in Nanodiamonds for Biomedical Applications** — •Ann Maria Tom[1], Marina Peters[1], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Muenster, Germany — [2]Department of Electrical Engineering and Computer Science, FH Muenster, Germany

Relaxometry with NV centers in nanodiamonds has emerged as a vital tool for detecting free radicals in medical diagnostics.[1] The transition of relaxometry to industrial applications faces challenges in optical optimization. This work explores an improved optical setup for these biomedical applications.

Key advancements include addressing optical challenges such as precise alignment, coupling efficiency, and robustness for industry-relevant scenarios. The use of glued optics and fiber-coupled solutions is explored to enhance system stability and scalability.[2] These improvements aim to bridge the gap between lab-based setups and practical industrial implementations, enabling more effective use of relaxometry in biomedical applications.

Q 48.45 Wed 17:00 Tent

**Towards quantum mirrors based on 2D subwavelength atomic arrays** — •Julian Lyne[1,2], Nico Bassler[2,1], Kai Phillip Schmidt[2], and Claudiu Genes[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstraße 2, D-91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander Universität Erlangen-Nürnberg (FAU), Staudtstraße 7, D-91058 Erlangen, Germany

Two-dimensional subwavelength arrays of quantum emitters have been shown to exhibit interesting optical properties, enabling perfect reflection of an incoming field as well as control over its polarization, phase, and helicity [1,2]. While such properties are already fully described by classical coupled dipole models, for incident fields of increased intensities, the quantum nature of the quantum emitters comes into play, as double excitation of an individual emitter is not possible. We investigate such regimes where the two-dimensional array can induce photon-photon interactions owing to the effective hardcore interaction. To this aim, we tailor the dipolar interaction as recently proposed in Ref. [3]. The manipulation of the emitters' dipole orientation and/or relative emitter-emitter separation allows for the confinement of excitations towards the center of the array and thus enhance photon-photon interactions. We show here the operation of such an array within the double excitation manifold.

[1] E. Shahmoon et al., Physical Review Letters 118, (2017).
[2] N. S. Baßler et al., Optics Express 31, 6003 (2023).
[3] M. Cech, I. Lesanovsky, and B. Olmos, Physical Review A 108, (2023).

Q 48.46 Wed 17:00 Tent

**Temporal-to-spatial mode demultiplexing of single photons for quantum information processing** — •Fuad Raed Jubran Haddad[1,2,3], Xavi Barcons Planas[1,4], and Janik Wolters[1,2,3] — [1]Technische Universität Berlin — [2]Deutsches Zentrum für Luft- und Raumfahrt — [3]PTB — [4]Humbodlt-Universität zu Berlin

Photonic quantum information processing needs the supply of many simultaneous input photons, separated into spatial modes. Single photon sources, such as SPDC sources or semiconductor quantum dots, typically produce time-separated photons in a single mode. By leveraging resonant electro-optic modulators (r-EOMs) to manipulate photon polarization, photons can be directed into optical paths of varying lengths [1]. This method enables the conversion of time-separated photons into spatially-separated photons, facilitating time-to-spatial demultiplexing, which is essential for interfacing with multimode photonic quantum processors. We report on our efforts to realize an efficient time-to-spatial demultiplexer for single photons, allowing to provide up to 8 photons simultaneously.

[1] C. Antón, et al., Optica 6, 1471-1477 (2019)

Q 48.47 Wed 17:00 Tent

**High-fidelity Stimulated Raman adiabatic passage** — •Julian

Dimitrov and Nikolay Vitanov — Center for Quantum Technologies, Faculty of Physics, Sofia University, James Bourchier 5 blvd., 1164 Sofia, Bulgaria

We present a comparative study of various approaches toward high-fidelity Stimulated Raman adiabatic passage (STIRAP). This technique for population transfer in a three-state quantum system is widely used because of its robustness to errors in the driving fields and the fact that the intermediate state is unpopulated in the adiabatic limit. Its main drawbacks are the large pulse areas needed to achieve adiabaticity and the necessity for a two-photon resonance between the two end states, which make it difficult to achieve very high population transfer efficiency. Here we compare two main approaches to high-efficiency STIRAP: by using pulse shaping of the driving fields and by using composite sequences. We assume that only two fields are present and discard the often used third field, which introduces unnecessary redundancy.

Q 48.48 Wed 17:00 Tent

**Hanbury Brown-Twiss interference of electrons in free space** — •Florian Fleischmann[1], Mona Bukenberger[2], Raul Corrêa[3], Anton Classen[4], Simon Semmler[1], Marc-Oliver Pleinert[1], and Joachim von Zanthier[1] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Quantum Optics and Quantum Information, 91058 Erlangen, Germany — [2]ETH Zürich, Department of Environmental Systems Science, 8092 Zürich, Switzerland — [3]Federal University of Minas Gerais, Departamento de Física, 31270-901 Belo Horizonte, Brazil — [4]University of Utah, Health Science Core, UT 84112 Salt Lake City, USA

We investigate the spatial second-order correlation function of two scattering electrons in a Hanbury Brown-Twiss like experiment. First, we consider semi-classically the effects of the Pauli exclusion principle and Coulomb repulsion on the expected correlation pattern. This is followed by a full quantum-mechanical treatment of the problem, where we separate the system into relative and center-of-mass coordinates in analogy to the Hydrogen atom ansatz. While the center-of-mass system is described as a free particle, the relative system contains the Coulomb scattering process which translates into an effective one-particle problem. We expand the respective initial state of the electrons in the eigenstates of the corresponding Hamiltonian and evolve the system in time. After the scattering process, the function is evaluated in the far field. We present the formal solution of the problem and discuss the current state of the numerical investigations.

Q 48.49 Wed 17:00 Tent

**Spin Control of Silicon-Vacancy Centers in Nanodiamonds** — •David Opferkuch, Andreas Tangemann, Marco Klotz, and Alexander Kubanek — Institute for Quantum Optics, University Ulm, Germany

Due to presumed high scalability, spin qubits in solid state hosts are promising candidates for the realization of quantum networks. As such, negatively charged silicon-vacancy-centers (SiV-) in nanodiamond (ND) combine the good spin properties of diamond with the good optical properties of group-IV defects. We are using highly strained SiV- hosted in ND, which demonstrate orbital ground state splittings exceeding 1THz. Thus, phonon induced dephasing of the spin qubit is mitigated at liquid Helium temperatures. Here, we present our current results on electron spin characterization and control of a SiV- in ND at liquid Helium temperatures as well as the characterization and control of coupled C13 nuclear spins.

Q 48.50 Wed 17:00 Tent

**Separation of Rubidium Isotopes for Atomic Vapor Cell Production** — •Timon Damböck[1], Robert Löw[2], and Ilja Gerhardt[1] — [1]light and matter group, Institute for Solid State Physics, Leibniz University of Hannover, Appelstrasse 2, 30167 Hannover — [2]5$^{th}$ Institute of Physics, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

In the past years, the fundamental research on atomic vapor quantum (sensing) systems made huge progress. With rising request of industrial applications for those systems, the demand for a production of high purity atomic vapor cells has increased. Although the used alkali metals (e.g. rubidium) are cheap and easily available, most of those quantum systems require purified isotopes for better control and higher sensitivity. The purification methods for isotopes are mostly inefficient and expensive, which limits the availability of enriched alkali isotopes on the market. This affects the cost and the advance from the transfer of scientific knowledge to industrial applications. To overcome this limitations, we propose an apparatus for the in–atomic–vapor–cells enrichment of rubidium isotopes using lasers, which can be used for the production of purified vapor cells from the natural abundance of the isotopes on. Combined with an outstanding collection efficiency, this could serve as a sustainer for the development of industrial applications using atomic vapor cells.

Q 48.51 Wed 17:00 Tent

**Emission statistics and strong-field energy spectra for electron photoemission from nanometric needle tips using non-classical light** — •Jonathan Pölloth[1], Jonas Heimerl[1], Andrei Rasputnyi[2], Stefan Meier[1], Maria Chekhova[1,2], and Peter Hommelhoff[1,2,3] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Max-Planck-Institut für die Physik des Lichts (MPL), 91058 Erlangen — [3]Department Physik, Ludwig-Maximilians-Universität München (LMU), 80799 München

Typical strong-field experiments investigate the interaction between intense classical light and matter, e.g. atoms or metal surfaces. This allows us to explore the electron dynamics in such a strong coherent light field. However, it is intriguing to study the influence of the driving state of light on strong-field effects. The development of intense sources of non-classical light such as bright squeezed vacuum (BSV) has made such studies experimentally feasible and thus established a new approach to the emerging field of strong-field quantum optics. When investigating nonlinear electron photoemission from needle tips using either coherent or BSV light, it was shown that the electron emission statistics is inherited from the photon statistics of the driving state of light [1]. Here, we will present these results as well as the first measurements of strong-field electron energy spectra driven by BSV. The study of these spectra allows to investigate also the strong-field electron dynamics in such an intense non-classical state of light.

[1] J. Heimerl *et al.*, Nat. Phys. **20**, 945-950 (2024)

Q 48.52 Wed 17:00 Tent

**Towards spatial demultiplexed feedforward of photon number states** — •Niklas Schröder[1], Frederik Thiele[1,2], Niklas Lamberty[1,2], Thomas Hummel[2], Sebastian Lengeling[3], Christof Eigner[2], Christine Silberhorn[3], and Tim Bartley[1,2] — [1]Department of Physics, Paderborn University,Warburger Str. 100, Paderborn, 33098, Germany — [2]Institute for Photonic Quantum Systems (PhoQS), Paderborn University, Warburger Str. 100, Paderborn, 33098, Germany — [3]Integrated Quantum Optics Group, Institute for Photonic Quantum Systems (PhoQS), Paderborn University, Warburger Str. 100, Paderborn, 33098, Germany

Measurement based manipulation of single photons enables many quantum photonic protocols. This can be achieved by measuring incident single photons and then controlling an electro-optic modulator. To do this efficiently, we combine integrated photonics and superconducting nanowire single photon detectors (SNSPD). We are working on a device which sorts heralded Fock states into different spatial modes. We start by measuring the photon number of the idler mode of a spontaneous parametric down-conversion source (SPDC) with a quasiphoton-number-resolving SNSPD. Based on the result, we will route the signal photons in an electro-optic demultiplexer via a cascade of couplers from a single input channel to four output channels, which correspond to a specific Fock state.

Q 48.53 Wed 17:00 Tent

**Optical setup for co-trapping $Yb^+$ and $Ba^+$ ions in a cryogenic trapped-ion quantum computer** — •Ernst Alfred Hackler, Daniel Busch, Patrick Huber, Dorna Niroomand, and Christof Wunderlich — Universität Siegen, Siegen, Germany

A novel cryogenic (4K) trapped ion quantum computer with integrated cryogenic control electronics (BMBF funded project ATIQ) requires an optical set-up for delivering laser light to cool and state selectively prepare and detect $Yb^+$ and $Ba^+$ ions. Here, we present the development process and simulation of all key components of this optical set-up. A major challenge in designing optics for the above-mentioned purpose is the wide wavelength range, which causes significant differences in dispersion and absorption for a given material. First, we introduce a new overlapping unit, which combines nine different wavelengths ranging from UV to near-IR in two separate arms. Second, we describe the achromatic beam delivery system, which transports the combined laser beams from the overlapping unit to the ions confined in a planar, micro-structured Paul trap within the cryostat. Third, we present a newly developed reflective imaging system based on a Schwarzschild objective designed by the Institute of Quantum Optics from Leibniz Universität Hannover that enables simultaneous imaging of all wavelengths in the experiment into one focal plane, in which the camera is placed. Since only two fluorescence wavelengths are relevant for state selective detection while all other wavelengths, along with stray light from the environment, presents background noise, we have designed a specifically tailored double bandpass filter to optimize detection.

Q 48.54 Wed 17:00 Tent

**Experimental set up for Trapped-Ion Experiments Using a Microfabricated Surface Paul Trap** — •Radhika Goyal, Tobias Pootz, David Stuhrmann, Celeste Torkzaban, and Christian Ospelkaus — Institute for Quantum Optics LUH, Hannover, Germany

With state of the art coherence times as well as gate fidelity demonstrations, trapped ions have become a cornerstone in the world of quantum computing. Ions can be trapped using various schemes, out of which microfabricated Surface Paul traps stand distinguished in QC applications for their compactness and scalability.

To house such a trap, we present a cryogenic vacuum setup designed for enhanced ion confinement and reduced environmental noise. The system features a custom-built cryostat operating at temperatures below 10 K and achieving ultra-high vacuum (UHV) levels of the order of 10e-8 mBar.

The system features multiple optical viewports for laser addressing, high-frequency RF electronics for trap operation, as well as an optical system to image the ions. This poster will detail the design, challenges, and performance benchmarks of the system, offering insights into its application in cutting-edge quantum research.

Q 48.55 Wed 17:00 Tent

**Miniaturizing optical resonators: Fiber-based Fabry-Perot cavities.** — •Usman Adil[1,2], Franziska Haslinger[2], Michael Förg[2], Thomas Hümmer[2], Jonathan Noé[2], and Manuel Nutz[2] — [1]LMU München — [2]Qlibri GmbH

Microscopic optical resonators have proven to be a versatile tool through their ability to enhance light-matter interaction. Constructing the mirrors on the end-facets of optical fibers offers a compact and tunable solution with intrinsic fiber coupling: Fiber Fabry-Perot Cavities (FFPCs). Successful experimental examples/applications range from non-destructive qubit readout in quantum information processing over sensing applications of gases or liquids to the usage as frequency filter for optical signals. Here, we present the prototype of a readily available FFPC and provide first insights on fiber alignment and positioning. Core parameters like finesse, length, stability and mode matching are analyzed/presented as a function of fiber type, mirror shape and coating properties.

Q 48.56 Wed 17:00 Tent

**Investigating Autofluorescence in Optical Fibers** — •Alexander Bukschat, Stefan Johansson, Dennis Lönard, Isabel Cardoso Barbosa, Jonas Gutsche, and Artur Widera — Physics Department and State Research Center OPTI- MAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

Autofluorescence describes the glow of photoactive substances when exposed to light. The autofluorescence that occurs in glass fibres often has a disruptive effect in experiments with miniaturized fluorescence-based sensors whose spectral ranges overlap. As the factors influencing the autofluorescence of glass fibers tend to receive little attention, we will now investigate and discuss in more detail. Not only the type of glass fiber plays a major role, but also the materials used, radii of curvature, contamination or errors during coupling. Our results thus resemble a guideline for the design and handling of glass fibers for miniaturized sensors.

Q 48.57 Wed 17:00 Tent

**Towards microwave-to-telecom transduction based on Erbium crystals** — •Mayssane Selmani and Andreas Reiserer — Technical University of Munich, TUM School of Natural Sciences and Munich Center for Quantum Science and Technology (MCQST), 85748 Garching, Germany

Superconducting qubits are among the most developed platforms for quantum information processing; however, they cannot be connected over long distances using microwave photons. Thus, the development of a device capable of converting microwave to optical photons at telecommunication wavelengths with high efficiency and bandwidth would be a key enabler for the communication between remote quantum computers. To realize such a transducer, we explore two different systems:

First, we investigate erbium doped crystals which can have well-suited optical and microwave properties for efficient transduction depending on the host material. The Erbium is integrated into resonators with high quality factor for both transitions.

Second, on the other end of the concentration scale, we explore stoichiometric crystals, in which Erbium is integrated as part of the lattice and not as a dopant. This results in a high concentration of erbium spins without compromising the inhomogeneous broadening. At low temperatures, these crystals order antiferromagnetically and display magnon modes that can be used for transduction.

We will present first results of both approaches and discuss their prospects for high-efficiency transduction.

Q 48.58 Wed 17:00 Tent

**Advanced fiber-optic interfaces – fiber cavities and beyond** — •Florian Giefer, Benedikt Beck, Daniel Stachanow, Lukas Tenbrake, Sebastian Hofferberth, and Hannes Pfeifer — Institute of Applied Physics, University of Bonn, Germany

Applications for fiber Fabry-Perot cavities (FFPCs) reach from the miniaturization of existing cavity QED systems to novel use-cases in optomechanics, sensing, laser technology and many more. In this contribution we present an overview over our current research on fiber interfaces and FFPCs in the Bonn Fiber Lab.

We showcase our progress in the development of fiber cavity interfaced micro-mechanical resonators that are fabricated via 3D direct laser writing, including Q-factor optimization techniques like dissipation dilution and glassy structures with higher intrinsic Q. We present a scannable vacuum-integrated fiber cavity setup for probing high quality-factor mechanical resonators for experiments with multi-resonator structures.

We further investigate the behavior of optically pumped dye molecules in fiber cavities for the development of a miniaturized, directly fiber coupled and widely tunable dye laser system.

For interfacing cold atoms we present our development of a miniaturized fiber to fiber setup with a free space slot in between. The needed fiber collimation lens system is fabricated with a 3D direct laser writing system (Nanoscribe) and will be used in an experiment to interface Rydberg Atoms.