Q 62: Poster – Quantum Information Technologies (joint session Q/QI)

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

Q 62.1 Thu 17:00 Tent

Design of a tweezer setup for rearrangement and addressing of single atoms in an optical cavity — •Micha Kappel, Raphael Benz, Sebastián Alejandro Morales Ramirez, Vincent Beguin, Krishna Relekar, and Stephan Welte — 5. Physikalisches Institut, Center for Integrated Quantum Science and Technology and CZS Center QPhoton, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Neutral atoms coupled to an optical cavity are a promising platform for implementing quantum network nodes. To realize network nodes with multiple stationary atomic qubits, it is crucial to position and address the atoms precisely within the cavity mode. We present an optical design utilizing two two-dimensional acousto-optical deflectors to create optical tweezers capable of trapping arrays of Rubidium atoms inside the cavity. This setup not only facilitates precise atom trapping but also enables individual addressing and rearrangement of the atoms.

To mitigate the inevitable atom losses during operation, we propose the inclusion of a reservoir containing additional atoms in a tweezer array outside the cavity mode. These extra atoms can be used to replenish lost atoms within the cavity. We describe our optical setup and discuss experimental techniques and challenges.

Q 62.2 Thu 17:00 Tent

Characterization and development of the Saarbrücken fiber link for memory-based quantum communication protocols — •Christian Haen[1], Max Bergerhoff[1], Jonas Meiers[1], Stephan Kucera[2], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken — [2]Luxembourg Institute of Science and Technology (LIST), Belveaux, Luxembourg

Deployed telecom glass fiber networks offer a basis for the wide-scale development of quantum networks, but characteristics of existing fibers, such as large loss and arrival time or polarization drifts through environmental exposure, must be addressed.

Previously, we demonstrated and characterized quantum network protocols on a 14-km long urban dark fiber link in Saarbrücken by transmitting photons from an SPDC source [1]. Now, we report on characterizing and developing the fiber link to allow for quantum network protocols using photons emitted by a ^{40}Ca$^+$ single-ion quantum memory, in order to demonstrate atom-photon entanglement and, based on this, device-independent quantum key distribution under realistic conditions.

[1] S.Kucera et al., npj Quantum Inf 10, 88 (2024)

Q 62.3 Thu 17:00 Tent

Two-cavity-mediated photon-pair emission by one atom — •Tobias Frank, Gianvito Chiarella, Pau Farrera, and Gerhard Rempe — Max Planck Institute for Quantum Optics, Hans-Kopfermann-Straße 1, 85748 Garching bei München

Single atoms coupled to high-finesse Fabry-Perot cavities provide a versatile quantum network node, enabling efficient generation, storage, and manipulation of photonic qubits with high fidelity. A key focus of ongoing research is to scale either the number of atoms coupled to the cavity or the number of cavity modes interacting with each atom. Our group achieved the latter by using two optical fiber based cavities which couple independently to a single atom in the high atom-photon cooperativity regime. This enables new quantum communication schemes, in which photonic qubits are either tracked by nondestructive qubit detection or received by an heralded quantum memory. In our recent work, we demonstrate an on-demand photon pair generation scheme [1] in which a single atom with three energy levels in a ladder configuration couples to two optical fiber cavities, generating photon pairs with an in-fiber emission efficiency of $\eta_{pair} = 16(1)\%$. We study the correlation properties of the emitted light and simulate the regime of strong atom-photon coupling, in which the atom emits photon pairs without populating the intermediate state. We propose a scenario to observe such a double-vacuum-stimulated effect experimentally.

[1] G Chiarella, T Frank, P Farrera, G Rempe. Optica Quantum Vol. 2, Issue 5, pp. 346-350 (2024)

Q 62.4 Thu 17:00 Tent

Device-independent quantum key distribution with atom-photon entanglement for an urban fiber link — •Jonas Meiers, Christian Haen, Max Bergerhoff, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken

Quantum cryptographic protocols offer physical security through no-cloning or entanglement. Following the entanglement-based quantum key distribution protocol of [1], we present our device-independent implementation with a ^{40}Ca$^+$-ion as quantum memory. The protocol requires four atomic bases and two photonic bases and allows us to create a quantum key with security verification via the Bell parameter. We employ polarization entanglement between a single trapped ^{40}Ca$^+$ ion and an emitted photon at 854 nm, generated via the $P_{3/2} \to D_{5/2}$ transition [2]. The photon is frequency-converted to the telecom band, enabling its transmission over our 15-km-long urban fiber link across Saarbrücken [3]. The fiber link has been characterized and stabilized for the transmission of polarization-encoded qubits. The projected qubits are error-corrected via a cascade algorithm to create the secure key and enable secure communication between the two nodes.

[1] R. Schwonnek et al., Nat. Commun. 12, 2880 (2021)
[2] M. Bock et al., Nat. Commun. 9, 1998 (2018)
[3] S.Kucera et al., npj Quantum Inf. 10, 88 (2024)

Q 62.5 Thu 17:00 Tent

Quantum Network Nodes with Cold Atoms in Optical Cavities — •Raphael Benz, Sebastián Alejandro Morales Ramírez, Micha Kappel, Vincent Beguin, Krishna Relekar, and Stephan Welte — 5. Physikalisches Institut, Center for Integrated Quantum Science and Technology and CZS Center QPhoton, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany.

The practical implementation of a quantum network remains an outstanding challenge pursued across various hardware platforms. Cold neutral atoms trapped in a high-finesse optical cavity have proven to be a promising platform due to the strong atom-light interaction and the controllability of the system. However, current implementations are limited to a few atoms in the cavity. The ability to position and individually control an array of atoms using optical tweezers opens the possibility of extending this platform to multi-qubit quantum network nodes. We present the plans of our group in Stuttgart to realize such a multi-qubit quantum network node. Several experiments are envisioned with this system, including photon-mediated quantum information processing between intra-cavity atoms, the generation of highly entangled photonic cluster states, and the creation of optical Gottesman-Kitaev-Preskill states.

Q 62.6 Thu 17:00 Tent

Setup and calibration of a single-photon spectrometer — •Jannis Sode, David Lindler, Marlon Schäfer, Tobias Bauer, and Christoph Becher — Universität des Saarlandes, Fachrichtung Physik, Campus E2 6, 66123 Saarbrücken

Fiber-based quantum networks consist of spin-photon interfaced quantum memory nodes utilizing flying qubits with wavelengths in the low-loss telecom bands. These photons are either directly generated via optical transitions or transducted using quantum frequency conversion. This enables communication and transfer of quantum states via preexisting optical fiber infrastructure. Due to the small signal level of the transmitted quantum states of light, it is mandatory to explore and control the noise sources in the transmission channels.

To this end, an exact spectral analysis of signals on the single-photon level is necessary to determine the spectral noise distribution. However, commercially available spectrometers typically have a small detection efficiency at infrared wavelengths.

In this contribution, we present the setup of a spectrometer able to measure single-photon signals in the telecom wavelength range (1500-1600 nm) using superconducting nanowire single photon detectors with high detection efficiency. We discuss the overall efficiency as well as the accuracy of the spectrometer.

Q 62.7 Thu 17:00 Tent

Towards fiber-integrated quantum frequency conversion in PPLN waveguides — •Felix Rohe, Marlon Schäfer, Tobias Bauer, David Lindler, and Christoph Becher — Universität des Saarlandes, Fachrichtung Physik, Campus E2 6, 66123 Saarbrücken

Quantum frequency conversion to the low-loss telecom bands is a key enabling technology for long-range fiber-based quantum networks.

While many state-of-the-art conversion devices use free-space coupling to nonlinear waveguides, for applications outside of a controlled lab environment, a more robust and compact design is desirable. One approach would be to substitute the free-space optics in favor of a fiber-based coupling scheme.

Here, we present the coupling of a solid-core photonic crystal fiber (PCF) to a periodically-poled lithium niobate (PPLN) waveguide. PCF are promising candidates for a fiber-integrated design because of their ability to simultaneously guide waves with a large difference in wavelength in the fundamental mode. We show coupling efficiencies of 637 nm signal and 2162 nm pump fields, as well as conversion efficiency and pump-induced noise rate for the difference frequency generation 637 nm - 2162 nm = 903 nm.

As an outlook, we present a concept for an "all-fiber" two-stage quantum frequency converter for NV-resonant photons, that does not use free-space optics. A two-stage conversion scheme was shown to yield very low noise rates in the conversion of SiV-resonant photons [1].

[1] Schäfer, M. et al., Adv Quantum Technol. 2023, 2300228

Q 62.8 Thu 17:00 Tent

Fabricating Tapered Optical Fibres for Quantum Networks — •Lasse Jens Irrgang[1], Timo Eikelmann[1], Mara Brinkmann[1], Tuncay Ulas[1], Donika Imeri[1,2], Konstantin Beck[1], Sunil Kumar Mahato[1], Rikhav Shah[1,2], and Ralf Riedinger[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

On the journey towards a quantum internet, the development of reliable quantum repeaters and quantum end-nodes is essential. Particularly well suited for usage as quantum bits for storing and processing quantum information in these applications are silicon vacancies in diamond. Crucial for this approach is a coupling of photonic quantum channels to the diamond, where the latter serves as a waveguide.

A recent solution for this challenge, outshining traditional methods, is the so-called adiabatic mode coupling using optical fibres. In this technique, a tapered optical fibre is positioned in contact with the top surface of the diamond waveguide, enabling highly efficient adiabatic coupling of light between the two waveguides. Presented here, is an automated etching setup for the fabrication of these tapered fibres. The silica glass etching process is based on hydrofluoric acid solution. The developed automated etching setup evidentially facilitates the fabrication of linearly tapered fibres with smooth etched surfaces. The customizable taper extends up to a few millimetres, corresponding to an angle of less than one degree between the fibre's centre axis and the tapered surface.

Q 62.9 Thu 17:00 Tent

Setup of a rack-mounted ion trap with integrated cavity — •Lara Becker[1], Jolan Costard[1], Stephan Kucera[1,2], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken — [2]Luxembourg Institute of Science and Technology, Belveaux, Luxembourg

For the realization of quantum networks, quantum repeaters [1] overcome the distance limitations due to propagation loss in direct transmission. Interfaces between single trapped ions and single photons [2] are promising building blocks for implementing a quantum repeater.

We are setting up a multi-segment Paul trap for ^{40}Ca^{+} ions with an integrated fiber cavity to increase the photon collection and generation efficiency of the interface. The trap consists of two laser-machined and metal-coated ceramic ferrules, into which the fiber cavity with sub-mm spacing is integrated. With its compact design, the trap-cavity system including the vacuum chamber, control electronics, ablation laser and photo-ionization laser will be stored in a single transportable rack. Its future implementation will enable quantum repeater protocols [3] over the Saarbrücken fiber link [4].

[1] H.-J. Briegel, et al., Phys. Rev. Lett. 81, 5932 (1998)
[2] M. Bock et al., Nat. Commun. 9, 1998 (2018)
[3] M. Bergerhoff, et al., Phys. Rev. A 110, 032603 (2024)
[4] S. Kucera, et al., npj Quantum Inf. 10, 88 (2024)

Q 62.10 Thu 17:00 Tent

AlGaAs Bragg Reflection Waveguides as Single and Entangled Photon Pair Source — •Akriti Raj[1], Tobias Bauer[1], David Lindler[1], Quankui Yang[2], Thorsten Passow[2], and Christoph Becher[1] — [1]Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken — [2]Fraunhofer-Institut für Angewandte Festkörperphysik IAF, Tullastr. 72, 79108 Freiburg

True single and entangled photon pair sources are crucial elements for applications in quantum technologies. Such sources may be realized by AlGaAs Bragg reflection waveguides, generating correlated single photon pairs through the process of spontaneous parametric down conversion (SPDC) [1]. The material AlGaAs is our preferred choice as the nonlinear medium because it features a high nonlinear coefficient, allows for room temperature operation and has the advantage of being a non-birefringent material. By using a type II SPDC process where the downconverted photons are orthogonally polarised to each other, the produced photons are inherently polarisation entangled eliminating the need for any additional entanglement setup [2]. We here present photon generation rates of 4×10^7 pairs/s/mW from these waveguides. The purity of the produced single photons is quantified by measuring the heralded $g^{(2)}(0) = 0.0017$ at ≈ 0.28 mW pump power. The photons show 91.9% entanglement fidelity with the $|\psi^+>$ Bell state and 90% purity. We thus realize a room temperature entangled pair photon source at 1546 nm that is already coupled in a standard single-mode telecom fiber for further applications. [1] F. Appas et al., J. Light. Technol. 40 (2022). [2] R. T. Horn et al., Sci. Rep. 3.1 (2013).

Q 62.11 Thu 17:00 Tent

Low Noise Quantum Frequency Conversion of Telecom Photons to SnV-Resonant Wavelengths — •David Lindler, Tobias Bauer, Marlon Schäfer, and Christoph Becher — Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken

Tin-Vacancy-Centers (SnV) in diamond represent a promising candidate for quantum nodes in quantum communication networks, featuring excellent optical and spin coherence [1,2]. To exchange the information between these nodes over long distances through optical fiber links, the spin state of the SnV-Center is transfered onto single photons. These photons are then converted into the low-loss telecom bands via quantum frequency down-conversion, to avoid the problem of high loss in fibers in the visible wavelength regime. After travelling trough the fiber, the reverse process, converting telecom photons back to the SnV-resonant wavelength, allows the photons to interact with another SnV-based quantum node once again.

We here present a two-stage low noise scheme for quantum frequency conversion of the telecom photons back to the SnV-resonant wavelength based on difference frequency generation in PPLN waveguides. The two step process drastically reduces noise at the target wavelength compared to the single step process [3]. We will present initial results on the conversion efficiency, conversion-induced noise count rates and the frequency stabilization of the mixing laser.

[1] J. Görlitz et al., npj Quant. Inf. 8, 45 (2022).
[2] I. Karapatzakis et al., Phys. Rev. X 14, 031036 (2024).
[3] M. Schäfer et al., Adv Quantum Technol. 2300228 (2023).

Q 62.12 Thu 17:00 Tent

Phase as the Measurement Quantity in Optically Detected Magnetic Resonance Setups With NV Centers — •Ludwig Horsthemke[1], Jonas Homrighausen[2], Ann-Sophie Bülter[1], Jens Pogorzelski[1], Dennis Stiegekötter[1], Frederik Hoffmann[1], Markus Gregor[2], and Peter Glösekötter[1] — [1]Department of Electrical Engineering and Computer Science, FH Münster — [2]Department of Engineering Physics, FH Münster

Measurements of optically detected magnetic resonance (ODMR) with nitrogen-vacancy (NV) centers usually observe the fluorescence intensity while applying a microwave radiation of varying frequency. We propose the phase between the excitation and the fluorescence as an alternative measurement quantity, offering a higher immunity to intensity fluctuations.

The fluorescence decay dynamics of NV centers act as a low pass filter in the frequency domain which changes its frequency response at the application of a resonant MW radiation. Upon intensity modulation of the excitation light at a frequency around 13 MHz we observe a contrast in the phase between excitation and fluorescence. We have previously shown that the phase has a high immunity to intensity fluctuations in all-optical magnetometry setups since we avoid the misinterpretation of changes in fluorescence intensity as changing magnetic fields [1]. In this work, we show the application of the phase measurement in a continuous wave ODMR setup.

[1] Horsthemke, L., et al. Excited-State Lifetime of NV Centers for All-Optical Magnetic Field Sensing. Sensors 24, 2093 (2024).

Q 62.13 Thu 17:00 Tent

Sol-gel process for bonding thin-film diamond — •Nick Brinkmann[1,2], Sunil Mahato[1,2], Rikhav Shah[1], Donika Imeri[1,2], Leonie Eggers[1,2], Konstantin Beck[1], Lasse Irrgang[1], and Ralf Riedinger[1,2] — [1]University of Hamburg, Faculty of Mathematics, Informatics and Natural Sciences, Department of Physics, Institute for Quantum Physics, Luruper Chaussee 149, 22761 Hamburg — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

Diamond nanophotonic structures hold immense potential for breakthroughs in quantum infomations technologies and are a leading platform for developing quantum memory chips.

One challenge in the development of nanophotonic structures lies in the reliable transfer and bonding of single crystal diamond thin-films onto suitable substrates.

Here we present an innovative and scalable method that utilizes a sol-gel process, which holds promise for efficiently and securely managing the transfer of these thin-film diamonds.

This method can elevate the fabrication of nanophotonic structures on diamonds, which can serve as interfaces between the spins of color centers, such as SiV, and photons.

Thus, it contributes to a new possibility for integrating such structures into photonic networks, promising significant advances in quantum optics and communication.

Q 62.14 Thu 17:00 Tent

Nanophotonic Quantum Network Nodes - Imaging of cryogenic Nanophotonics — •Leonie Eggers[1,2], Timo Eikelmann[1], Donika Imeri[1,2], Caius Niemann[1], Konstantin Beck[1], Rikhav Shah[1], Mara Brinkmann[1], Lasse Irrgang[1], Nick Brinkmann[1,2], Sunil Mahato[1,2], and Ralf Riedinger[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

Silicon vacancies (SiV) in diamond combined with nanophotonic cavities are a promising platform for network-based quantum solid-state processors, due to their optically addressable spin transition and high noise tolerance. Paired with a fiber network this can enable efficient long-distance quantum communication and a modular approach to building larger quantum processors.

As temperature below 300 mK are needed for the SiV to have long-lived spin degrees of freedom, we show a high- resolution confocal imaging system that can image the nanophotonics on the diamond samples inside a cryostat. This improves our ability to couple optical fibers to the nanophotonics in-situ while operating the cryostat, enabling our research on building nanophotonic quantum network.

Q 62.15 Thu 17:00 Tent

Resolving the Low-Field Ambiguity in All-Optical Magnetometry in Resource Constrained Devices — •Ann-Sophie Bülter[1], Ludwig Horsthemke[1], Jens Pogorzelski[1], Dennis Stiegekötter[1], Frederik Hoffmann[1], Sarah Kirschke[2], Markus Gregor[2], and Peter Glösekötter[1] — [1]Department of Electrical Engineering and Computer Science, FH Münster — [2]Department of Engineering Physics, FH Münster

Machine learning algorithms offer a promising solution for unambiguous magnetic field determination in all-optical fluorescene intensity measurements with nitrogen-vacancy (NV) centers, addressing the ambiguity below 8 mT [1].

To continue this work, we exploit the dependency of the phase and the magnitude of the fluorescence on both the magnetic field and frequency, applying advanced regression techniques. The primary focus of our study is to investigate the effect of feature engineering to enhance the accuracy of magnetic field determination. By comparing the results of feature-engineering approaches with those using raw data alone, we demonstrate the potential of machine learning for precise and reliable magnetic field measurements in all-optical magnetic field sensing. Additionally, we assess the resource efficiency of these methods to ensure their feasibility for the implementation on a microcontroller.

[1] Horsthemke, L., et al. Towards Resolving the Ambiguity in Low-Field, All-Optical Magnetic Field Sensing with High NV-Density Diamonds. Engineering Proceedings 68, 8 (2024).

Q 62.16 Thu 17:00 Tent

Diamond Membrane with Strained SiV Color Centers Coupled to a Fabry-Perot Microcavity — •Robert Berghaus[1], Florian Feuchtmayr[1], Selene Sachero[1], Gregor Bayer[1], Julia Heupel[2], Tobias Herzig[3], Jan Meijer[3], Cyril Popov[2], and Alexander Kubanek[1] — [1]Institut für Quantenoptik, Universität Ulm — [2]Institute of Nanostructure Technologies and Analytics, University of Kassel — [3]Felix Bloch Institute for Solid State Physics, University Leipzig

Group IV color centers in diamond, such as silicon vacancy (SiV), are promising for quantum optics because of their optical transitions, spin access, and good coherence properties. SiV centers typically require millikelvin temperatures, but increasing the ground state splitting improves coherence, allowing operation at higher temperatures. Here, we demonstrate the integration of a single-crystal diamond membrane into a high-finesse microcavity (F = 3000), achieving significant lifetime shortening with a Purcell factor of 2.2 in a liquid helium atmosphere. Absorption and strain spectroscopy confirm enhanced ground-state splitting, paving the way for a spin-photon interface.

Q 62.17 Thu 17:00 Tent

Flex-PCB Integrated Quantum Sensor With NV Centers in Diamond (FleQS) — •Jens Pogorzelski[1], Jonas Homrighausen[2], Ludwig Horsthemke[1], Ann-Sophie Bülter[1], Frederik Hoffmann[1], Dennis Stiegekötter[1], Markus Gregor[2], and Peter Glösekötter[2] — [1]Department of Electrical Engineering and Computer Science, FH Münster — [2]Department of Engineering Physics, FH Münster

The utilisation of nitrogen-vacancy (NV) centers in diamond microcrystals for quantum magnetometry represents a promising approach for the development of sensitive, integrated magnetic field sensors [1]. Nevertheless, the cost and complexity of the technology have thus far limited its application. This study presents the most compact, fully integrated quantum sensor based on LED excitation, which represents an evolution of previous designs [2]. The sensor integrates all essential components, including a pump light source, photodiode, microwave antenna, optical filters and fluorescence detection, in a compact system that requires no external optical adjustments. The assembly is constructed on a flexible, foldable printed circuit board with surface-mounted components and a laser-cut optical filter. The PCB is folded and moulded. Furthermore, the random alignment of the NV axes is determined. The result is a 3.8x3.1 mm sensor head with a sensitivity of 68 nT/Hz^1/2, representing a miniaturization of quantum magnetometers.

[1] Stürner, F.M. et al., 2021. Advanced Quantum Technologies 4.

[2] Pogorzelski, J. et al., 2024. Sensors 24, 743.

Q 62.18 Thu 17:00 Tent

Quantum frequency conversion device for single photons from SnV centers in diamond — •Marlon Schäfer, David Lindler, Tobias Bauer, and Christoph Becher — Universität des Saarlandes, Fachrichtung Physik, Campus E2 6, 66123 Saarbrücken

Most quantum emitters exhibit optical transitions in the visible to near-infrared spectral region. In fiber-linked quantum networks, these photons need to be converted to low-loss telecom bands at 1550 nm through nonlinear three-wave mixing in periodically-poled lithium niobate waveguides to minimize transmission losses.

To make this technology viable for real-world applications, quantum frequency converters must operate robustly outside laboratory conditions without human intervention. Here, we explore automatic beam alignment and path stabilization for a device that converts single photons from tin-vacancy (SnV) centers in diamond using a two-stage scheme. Such a two-stage scheme was recently shown to successfully circumvent pump-induced noise for the conversion of single photons from silicon-vacancy centers in diamond [1].

[1] Schäfer, M. et al., Adv. Quantum Technol. 2023, 2300228.

Q 62.19 Thu 17:00 Tent

Towards a spin-exchange collision-based optical quantum memory in noble-gas spins — •Alexander Erl[1,2], Norman Vincenz Ewald[1,2], Andrés Medina Herrera[2], Denis Uhland[3], Wolfgang Kilian[2], Jens Voigt[2], Ilja Gerhardt[3], and Janik Wolters[1,4] — [1]DLR, Institute of Optical Sensor Systems, Berlin — [2]PTB, 8.2 Biosignals, Berlin — [3]LUH, Institute of Solid State Physics, Hannover — [4]TUB, Institute of Optics and Atomic Physics, Berlin

A critical limitation on current room-temperature quantum memory systems [1] is the maximum achievable storage time on the order of a few μs, which must be extended for various quantum communication applications, such as unforgeable quantum tokens for authentication. We report on our first steps towards a long-lived quantum memory with an all-optical interface based on a mixture of ^{129}Xe noble gas and ^{133}Cs alkali metal vapor, both confined in a glass cell at near room temperature. The interface relies on EIT, implemented through a Λ-scheme in the Zeeman sublevels of the long-lived hyperfine ground states of ^{133}Cs, coupled to an excited state via the D$_1$ line at 895 nm [2]. Spin-exchange collisions in the strong coupling regime are envisioned to transfer the stored information from the alkali vapor to the noble gas [3]. The coherence time of ^{129}Xe, which can extend up to several hours [4], offers the potential for long-term storage of quantum information in collective atomic excitations. [1] M. Jutisz et al., arXiv:2410.21209 (2024) [2] G. Buser et al., PRX, 020349 (2022) [3] O. Katz et al., PRA 105, 042606 (2022) [4] C. Gemmel et al., EPJ D 57, 303-320 (2010)

Q 62.20 Thu 17:00 Tent

Optimal control solutions for nuclear spin polarization of nitrogen-vacancy (NV) centers in diamond — •René Wolters[1], Matthias Müller[1], Felix Motzoi[1], and Tommaso Calarco[1,2] — [1]Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, Germany

The topic of nuclear spin polarization in colour center platforms, including NV centers in a diamond lattice or silicon carbide, has attracted considerable interest in recent years. This is due to the favourable conditions for quantum sensory devices and the storage of quantum states that are enabled by the long coherence time of the nuclear spins and their operability at room temperature. The defining characteristic of colour centers is that the electronic spin state of the center can be both initialized and read out via laser irradiation in the visible wavelength spectrum. Dynamical nuclear polarization (DNP) techniques are employed with the objective of transferring the spin polarization from the electronic to the surrounding nuclear spins. We employ quantum optimal control to optimize DNP pulses in terms of both time and error resilience, with regard to the polarization of single or few well-defined nuclear spins in a weak magnetic field which can be addressed and controlled individually. The weak magnetic field permits longer coherence times and simpler implementation with fewer errors. Furthermore, we investigate how to polarize the nuclear spins with the minimal possible number of initializations of the electron spin, to reduce disruption of the laser irradiation.

Q 62.21 Thu 17:00 Tent

Frequency Stabilization of a Hybrid SnV-^{40}Ca^{+} Interface at Telecom Wavelengths — •Tobias Bauer, David Lindler, Max Bergerhoff, Jürgen Eschner, and Christoph Becher — Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken

In quantum networks, the synchronization of dissimilar quantum nodes requires precise frequency control and efficient wavelength conversion. We demonstrate a platform combining optical frequency comb technology with quantum frequency conversion to integrate SnV color centers in diamond and trapped ^{40}Ca^{+} ions into a common telecom-wavelength framework.

Our setup employs two mutually stabilized frequency combs as precise frequency references for all system lasers at each node. We characterize the system with classical light by stabilizing the excitation lasers at the SnV (619 nm) and ^{40}Ca^{+} (854 nm) system wavelengths to their respective frequency combs. These lasers are then frequency-converted to a common telecom wavelength (1550 nm) using pump lasers that are likewise referenced to the combs. The successful operation of our complete stabilization scheme is demonstrated through beat note measurements between the converted lasers at the telecom wavelength, verifying the frequency precision required for future quantum network applications.

Q 62.22 Thu 17:00 Tent

Automated Electrode Routing Routine for Surface Electrode Paul Traps for Quantum Computing — •Axel Hoffmann[1], Florian Ungerechts[2], Rodrigo Munoz[2], Janina Bätge[2], Masum Billah[2], Maximilian Kanz[1], Dirk Manteuffel[1], and Christian Ospelkaus[2,3] — [1]Institut für Hochfrequenztechnik und Funksysteme, Leibniz Universität Hannover, Appelstr. 9A, 30167 Hannover, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [3]Physikalisch-Technische Bundesanstalt, Bundesallee 100,38116 Braunschweig, Germany

Trapped-ion quantum processors based on surface electrode Paul traps with integrated microwave conductors for near-field quantum control are a promising approach for scalable quantum computers. Due to increasing complexity of the processor chip models numerical analysis of the cause-effect relationship becomes challenging. In a complex multi-zone processor chip architecture, it is known that the electrode routing affects the ion transport, trapping and state control. To overcome these challenges already in the first design step, an automated electrode routing routine is proposed. Applying an iterative Method of Moments simulation process, cross-talk can be avoided while keeping the computational costs feasible. Challenges and benefits compared to straight forward approaches are discussed.

Q 62.23 Thu 17:00 Tent

Towards quantum computation with Sr atom arrays — •Eran Reches[1,3], Kevin Mours[1,3], Robin Eberhard[1,3], Dimitrios Tsevas[1,3], Zhao Zhang[1,3], Lorenzo Festa[1,3], Max Melchner[1,2,3], Andrea Alberti[1,2,3], Sebastian Blatt[1,2,3], Johannes Zeiher[1,2,3], and Immanuel Bloch[1,2,3] — [1]Max-Planck Institut für Quantenoptik, 85748 Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, 80799 Munich, Germany — [3]Munich Center for Quantum Science and Technology, 80977 Munich, Germany

We report on the recent progress of the MQV quantum computing demonstrator based on neutral Sr atoms trapped in arrays of optical tweezers. We have shown high-fidelity detection, single- and two-qubit operations as well as state-of-the-art vacuum-limited lifetime in a non-cryogenic platform. We further present our ongoing work on the realization of highly parallel atom moves, setting the stage for future implementations of brickwall-type digital circuits.

Q 62.24 Thu 17:00 Tent

Towards fully chip-integrated optical and near-field microwave control of trapped-ion qubits — •Mohammad Masum Billah[1,2], Florian Ungerechts[1], Rodrigo Munoz[1], Janina Bätge[1], Axel Hoffmann[1,4], Giorgio Zarantonello[1,3], Christopher Reiche[1,2], and Christian Ospelkaus[1,2,5] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover — [3]QUDORA Technologies GmbH — [4]Institut für Hochfrequenztechnik und Funksysteme, Leibniz Universität Hannover — [5]Physikalisch-Technische Bundesanstalt

To fully harness the capabilities of surface-electrode trapped ion quantum computers, a large number of qubits is essential. Scalable ion traps are critical for accommodating these qubits, but also require a significant number of free-space lasers for qubit state preparation as well as for readout, cooling and optical quantum gates. While microwave near-field gate operations can reduce the need for the latter lasers, achieving full scalability necessitates the integration of optical waveguides and grating couplers within the trap chip for effective qubit control. This integration poses novel challenges in ion trap design and the microfabrication processes used to create the corresponding chips. Our study addresses key issues such as the impact of optical windows in the chip on trapping potentials, DC shuttling operations, and specifically, the effects on microwave near-field interactions. We further explore the implications of these integrations and discuss the increasing complexity in fabricating such highly integrated ion traps.

Q 62.25 Thu 17:00 Tent

Hybrid Quantum Photonics With One Dimensional Photonic Crystal Cavities and Silicon Vacancy Centers In Nanodiamonds — Lukas Antoniuk[1], Niklas Lettner[1,2], •Tim Mülleneisen[1], Anna P. Ovvyan[3,5], Daniel Wendland[3], Viatcheslav N. Agafonov[4], Wolfram H.P. Pernice[3,5], and Alexander Kubanek[1,2] — [1]Institute for Quantum Optics, Ulm University, Germany — [2]Center for Integrated Quantum Science and Technology (IQst), Ulm University, Germany — [3]Institute of Physics and Center for Nanotechnology, University of Münster, Germany — [4]Universite F. Rabelais, 37200 Tours, France — [5]Heidelberg University, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany

Scaling up current quantum hardware to large numbers of their qubit building blocks is the one of the most pressing challenges in modern quantum technologies. To achieve this, one could separate qubits physically and mediate interaction between them by flying qubits. However, therefore one requires high interaction strength between the stationary and flying qubits. Here, we summarize our efforts to combine silicon nitride photonics and negatively charged silicon vacancy centers hosted in nanodiamonds to achieve this and build up a scalable interface between light and matter on the basis of this hybrid approach.

Q 62.26 Thu 17:00 Tent

Progress towards a novel apparatus for unit testing of ion transport and quantum logic protocols in context of QVLS-Q1 — Christian Joohs[1,2], Markus Duwe[1,2], •Alexander Onkes[1,2], Hardik Mendpara[1,2], and Christian Ospelkaus[1,2] —

[1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]PTB, Bundesallee 100, 38116 Braunschweig

We report on the progress of the QVLS-Q1 supporting experiment. It is being developed to test and characterize ion transport and EIT cooling. The trap is a surface electrode Paul trap, which means that the trapped ions have two-dimensional freedom of movement above the trap. It comprises a register-like design with different zones for trapping, storage, readout and quantum logic operations (termed QCCD architecture [1,2]). Here we report on updates of the experimental setup, specifically on progress of the optical and vacuum setup. Furthermore, we present the first steps towards a cloud interface to allow easy access for future collaborations.

[1] D.J. Wineland et al., J. Res. Natl. Inst. Stand. Technol. 103, 259 (1998)

[2] D. Kielpinski et al., Nature 417, 709 (2002)

Q 62.27 Thu 17:00 Tent

Fermionic State Preparation and Imaging in Tweezer Arrays — •Kirill Khoruzhii[1,3], Naman Jain[1], Marcus Culemann[1], Jin Zhang[1], Xinyi Huang[1], Pragya Sharma[1], Jun Ong[1], and Philipp Preiss[1,2] — [1]Max Planck Institute of Quantum Optics, Garching — [2]Ludwig-Maximilians-Universität, Munich — [3]Munich Center for Quantum Science and Technology

We demonstrate a platform for deterministic preparation of ultracold fermionic lithium-6 atoms in a tweezer array, combined with rapid and high-fidelity free-space spin-resolved imaging. This system enables programmable initialization of atomic arrays, providing a foundation for hybrid tweezer/lattice experiments and quantum simulation. Atoms are loaded into a tweezer array generated by two orthogonally oriented acousto-optic deflectors (AODs). Using magnetic field gradients for controlled atom spilling, we prepare pairs of spin-up and spin-down atoms in the ground state of each tweezer with over 90% success rate. The entire experiment cycle is completed in under 2 seconds. Uniformity of the AOD-generated tweezer array is ensured through model-based optimization, achieving intensity homogeneity to within 1% for arrays up to 10x10 tweezers. This consistency is crucial for reliable state preparation. For imaging, counter-propagating resonant beams illuminate the atoms for 20 μs and enable free-space single atom detection with a fidelity exceeding 95%. Spin states are distinguished by polarization-dependent fluorescence, with photons spatially separated and directed to the camera. This platform will be used to realize a fermionic many-body interferometer.

Q 62.28 Thu 17:00 Tent

Developing a photon-pair source for quantum repeaters — •Henning Mollenhauer — DLR Berlin-Adlershof, Berlin — TU-Berlin, Berlin

We are reporting on the development of a photon-pair source for signal and idler photons at 894nm and 1550nm. The underlying process is spontaneous parametric down-conversion (SPDC) inside a periodically poled KTP crystal. To achieve spectrally pure and narrow-band characteristics for signal and idler photons our ppKTP crystal is designed as a monolithic cavity [1]. Pulsed pump light at 567nm for the SPDC process is produced in sum frequency generation from the target wavelengths. For the future we plan to interface our photon source with a single-photon quantum memory [2], to build a demonstrator of a quantum repeater. [1] Mottola et al. (2020) [2] Jutisz et al. (2024)

Q 62.29 Thu 17:00 Tent

Tin-vacancy centers in photonic crystal cavities in diamond — •Daniel Bedialauneta Rodriguez, Tim Turan, Nina Codreanu, and Ronald Hanson — Delft University of Technology

Color centers in diamond are a promising platform for realizing quantum networks as a spin-photon interface that also gives access to naturally occurring 13C memory qubits. The nitrogen-vacancy (NV) center has been successfully used to realize a three-node quantum network. However, its low emission rate of coherent photons and sensitivity to surface charges makes scaling to more nodes difficult.

The tin-vacancy (SnV) center has emerged as a compelling alternative due to its favorable optical properties and compatibility with nanophotonic structures. Here, we present the integration of SnV centers into photonic crystal cavities. These cavities promise to enhance the light-matter interaction, ultimately boosting the rate of entanglement between nodes. We measure cavity properties at cryogenic temperatures and demonstrate in-situ frequency tuning through gas desorption. We use this technique to probe the cavity-SnV system.

Q 62.30 Thu 17:00 Tent

Neutral Ca fluorescence during ablation loading for surface ion traps — •David C Stuhrmann[1], Radhika Goyal[1], Tobias Pootz[1], Sascha Agne[2], Celeste Torkzaban[1], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Surface electrode ion traps are well suited for building a scalable quantum computer because ions trapped in a Paul trap can have long coherence times combined with high fidelities. For trapping 40Ca+ ions I need to generate a stream of individual ions reaching the trap center. This is achieved by a laser ablation process together with a two step photo-ionization which uses a resonant 423nm laser and free-running 375nm laser. As a measure of the amount of released Ca atoms from ablation I study neutral Ca fluorescence with the 423nm resonant transition. The time resolved fluorescence signal is used to scan the laser powers and positions. A frequency scan of the 423nm beam shows how many atoms of a certain velocity class get released and that a detuning of 500 MHz or less are desirable. The signal strength is also used for finding the optimal horizontal and vertical position of ablation laser as well as determining the ablation threshold. The results show that our ablation setup is suited for generating Ca+ ions and that we can adjust our various laser parameters.

Q 62.31 Thu 17:00 Tent

Transport through a 1D channel with an epitaxial GaAs quantum dot in its vicinity — •Selma Delić[1,2], Paola Atkinson[3], Xuelin Jin[1,2], Nataliya Demarina[1], Detlev Grützmacher[1,2], and Beata Kardynał[1,2] — [1]PGI, Forschungszentrum Jülich, 52428 Jülich, Germany — [2]2 Department of Physics, RWTH, 52074 Aachen, Germany — [3]Institut des Nano Sciences de Paris, CNRS UMR 7588, Sorbonne Université, 75005 Paris, France

Gate-defined quantum dots (GDQD) in GaAs/AlGaAs heterostructures host spin qubits which are potentially scalable and which, thanks to the direct bandgap of GaAs, may be addressable optically. High fidelity transfer of quantum information from a photon to the electron spin in the gated qubit can be mediated by photon absorption in a self-assembled GaAs quantum dot (SAQD) [1] followed by adiabatic transfer of the photo-generated electron into the GDQD [2].

In this contribution, we present the results of our studies of the transport and optical properties of nanostructures defined by gates in GaAs/AlGaAs heterostructures with embedded SAQDs. SAQDs are tunnel coupled to the gated nanostructures. We study the effect of the quantum states in the SAQD on the electron transport characteristics of a 1D channel. Further, we discuss the impact of the lateral alignment of the gates relative to the SAQD on the device characteristics. Based on our findings, we present a potential design of the heterostructures for the spin-photon interface and the design of the devices.

[1] P. Atkinson et al., Jrn. Appl. Phys. 112, 054303 (2012)

[2] B. Joecker et al., Phys. Rev. B 99, 205415 (2019)

Q 62.32 Thu 17:00 Tent

Fabrication and Characterization of Photonic Nanostructures in Diamond for Quantum Applications — •Jonathan Ensslin, Colin Sauerzapf, Oliver von Berg, Rainer Stöhr, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart

The unique optical properties and long-lived spin coherence times of color centers in diamond make them a promising platform for quantum technologies [1]. This work focuses on the fabrication and characterization of photonic nanostructures, such as free-standing optical waveguides, capable to enhance collection efficiency [2] and spin-photon interaction [3]. Fabrication techniques, including anisotropic reactive ion beam etching (RIBE), were optimized to achieve precise control over waveguide dimensions and etch profiles, highlighting the advances of RIBE over inductively coupled plasma etching [4, 5]. By tailoring etching parameters, stable processes for both straight and angled etches were developed, improving reproducibility and selectivity. We investigated etch rates, angular dependencies, and mask material selectivity. These developments pave the way for creating diamond nanostructures capable of hosting color centers, ultimately facilitating their integration with optical cavities. Future work includes optical characterization of the structures and the fabrication of defect-hosting waveguides for scalable quantum devices. [1] M. Pompili et al., Science 372, 259-264, (2021) [2] M. Krumrein et al., ACS Photonics 11

(6), 2160-2170, (2024) [3] L. Childress et al., Science Advances, vol. 4, no. 1, pp. 12-18, (2021) [4] H. A. Atikian et al., APL Photonics 2 (5), 051301, (2017) [5] C. Chia et al., Opt. Express 30, 14189-14201 (2022)

Q 62.33 Thu 17:00 Tent

Towards experimental implementation of a free-space continuous-variable quantum key distribution scheme with unidirectional modulation of squeezed states — •Jan Schreck[1,2], Thomas Dirmeier[1,2], Kevin Jaksch[1,2], and Christoph Marquardt[2,1] — [1]Max Planck Insitute for the Science of Light, Erlangen, Germany — [2]Chair of Optical Quantum Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

Continuous-variable quantum key distribution (CV-QKD) offers a chance to create quantum-safe cryptography. Polarization is a promising degree of freedom to encode QKD signals in free-space optical (FSO) links. Furthermore, a experimental CV-QKD implementation by unidirectional modulation of polarization squeezed states of light can increase CV-QKD's resilience to channel noise and finite post-processing efficiency. In addition, supression of information leakage to potential eavesdroppers is possible. This work presents our idea of a quantum signal source generating squeezed states of light and the concept of the optical sender and receiver.

Q 62.34 Thu 17:00 Tent

Multiplexing and Signal Optimization in Surface-Electrode Ion Trap Quantum Processors — •Janina Bätge[1], Florian Ungerechts[1], Rodrigo Munoz[1], Mohammad Masum Billah[1], Axel Hoffmann[1,2], Giorgio Zarantonello[1,3], and Christian Ospelkaus[1,4] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]Institut für Hochfrequenztechnik und Funksysteme, Leibniz Universität Hannover, Germany — [3]QUDORA Technologies GmbH, Braunschweig, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Scaling up ion trap quantum processors requires efficient management of control signals for the increasing number of control electrodes. We present three methods to minimize the number of signals by controlling multiple electrodes with shared inputs. The first method uses a bucket brigade for ion storage. The second employs switching electronics to sequentially charge multiple electrodes with a single signal. The final method uses switches to multiplex the control signals for ion transport through an X-junction. In this approach, it is crucial to optimize the assignment of electrodes to signals and determine the minimal number of signals needed for efficient shuttling.

Q 62.35 Thu 17:00 Tent

Efficient simulation workflow for designing micro-structured planar Paul traps — •Kais Rejaibi, Dorna Niroomand, Patrick Huber, Rodolfo Muñoz Rodriguez, and Christof Wunderlich — Department of Physics, School of Science and Technology University of Siegen, 57068 Siegen, Gemany

When developing novel micro-structured traps for quantum science with trapped ions, design considerations include, for instance, precise ion shuttling, suppressing micromotion, and ensuring robust quantum state control in quantum experiments. To be able to efficiently design novel traps, we have developed a simulation workflow that uses the Boundary Element Method (BEM) to accurately model electric fields from complex electrode geometries such as microfabricated surface ion traps incorporating the Magnetic Gradient Induced Coupling (MAGIC) scheme and effectively handling open boundary conditions with low computational overhead.

By applying solid harmonics decomposition to the simulated fields, we identify and mitigate higher-order multipole components that lead to residual micromotion and other effects. This process allows us to iteratively refine electrode designs and generate precise voltage control configurations, optimizing micromotion compensation and improving ion transport. Our approach focuses on simulation and analytical techniques for designing ion traps capable of reliable shuttling through varying magnetic fields. By streamlining the development process, we enhance the performance of traps, contributing to more robust and scalable implementations in quantum computing applications.

Q 62.36 Thu 17:00 Tent

Single qubit addressing in a 2D array of neutral Ytterbium atoms — •Clara Schellong[1], Tobias Petersen[1], Nejira Pintul[1], Jonas Rauchfuss[1], Jan Deppe[1], Carina Hansen[1], Till Schacht[1], Frederik Mrozek[1], Koen Sponselee[1], Alexander Ilin[1], Klaus Sengstock[1,2], and Christoph Becker[1,2] — [1]Center of Optical Quantum Technologies University of Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Institute for Quantum Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg

Neutral atoms have shown to be a promising candidate for building large scale quantum computers and quantum simulators, with fast high-fidelity single and two-qubit gates as well as flexible initialisation and readout. Recently, alkaline earth (-like) atoms such as Ytterbium (Yb) have shown to offer promising ways to overcome some of the main challenges on the road to scalable and flexible quantum simulators with decent effective circuit depth. Additionally, an optical coherent qubit mapping scheme enables mid-circuit measurements and advanced error correction techniques.

We will present different manipulation and addressing techniques for optimised and spatially resolved single- and two-qubit operations in a two-dimensional array of neutral Yb atoms.

Q 62.37 Thu 17:00 Tent

Real-time QKD with a deterministic sub-poissonian Source on an Intercity Scale — •Joscha Hanel[1], Jingzhong Yang[1], Jipeng Wang[1], Vincent Rehlinger[1], Zenghui Jiang[1], Frederik Benthin[1], Tom Fandrich[1], Jialiang Wang[1], Fabian Klingmann[2], Raphael Joos[3], Stephanie Bauer[3], Sascha Kolatschek[3], Ali Hreibi[4], Eddy Rugeramigabo[1], Michael Jetter[3], Simone Portalupi[3], Michael Zopf[1,5], Peter Michler[3], Stefan Kück[4], and Fei Ding[1,5] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Fraunhofer-Institut für Photonische Mikrosysteme, Dresden — [3]Institut für Halbleiteroptik und Funktionelle Grenzflächen, IQST and SCoPE, University of Stuttgart — [4]Physikalisch-Technische Bundesanstalt, Braunschweig — [5]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover

While quantum key distribution (QKD) is among the most mature quantum technologies today, it remains a considerable challenge to achieve practical transmission rates over long distances with sub-poissonian photon sources. However, use of such sources is desirable in the long run, as they facilitate integration into future receiver-based networks.

We present a polarization-based BB84-QKD system using a quantum dot (QD) as a bright, pure, and deterministic single photon source that emits into the telecom C-band. We employ active polarization stabilization and both spectral and temporal filtering to demonstrate positive secure key rates in the kbit/s range for transmission distances on the intercity scale.

Q 62.38 Thu 17:00 Tent

Sparse Optimization of Two-Dimensional Terahertz Spectroscopy — •zhengjun wang — University of Hamburg Institute for Quantum Physics Luruper Chaussee 149 22761 Hamburg

two-dimensional terahertz spectroscopy (2DTS) is a low-frequency analogue of two-dimensional optical spectroscopy that is rapidly maturing as a probe of a wide variety of condensed matter systems. However, a persistent problem of 2DTS is the long experimental acquisition times, preventing its broader adoption. A potential solution, requiring no increase in experimental complexity, is signal reconstruction via compressive sensing. In this work, we apply the sparse exponential mode analysis (SEMA) technique to 2DTS of a cuprate superconductor. We benchmark the performance of the algorithm in reconstructing the terahertz nonlinearities and find that SEMA reproduces the asymmetric photon echo lineshapes with as low as a 10

Q 62.39 Thu 17:00 Tent

Simulating a Many-Body System with Waveguide Arrays — •Florian Huber[1,2,3], Benedikt Braumandl[1,2,3,4], Carlotta Versmold[1,2,3], Jan Dziewior[1,2,3], Robert Jonsson[5], Johannes Knörzer[6], Alexander Szameit[7], and Jasmin Meinecke[1,2,3,8] — [1]Max-Planck-Institut für Quantenoptik, Germany — [2]Ludwig-Maximilians-Universität, Germany — [3]Munich Center for Quantum Science and Technology, Germany — [4]Technische Universität München, Germany — [5]Nordita, KTH Royal Institute of Technology and Stockholm University, Sweden — [6]ETH Zurich, Switzerland — [7]Universität Rostock, Germany — [8]Technische Universität Berlin, Germany

Waveguide arrays, femtosecond laser-written into fused silica, are a versatile, still well-controllable simulation platform. If the distance between the laser written channels is large compared to the transversal mode size of each waveguide the system can be described by a nearest neighbor coupling Hamiltonian. The possibility to change the propagation and coupling constants in the manufacturing process allows the simulation of a large class of tridiagonal Hamiltonians. In our case the coupling and propagation constants of the waveguide array describing a giant atom system can be found by applying a Lanczos transformation to its interaction Hamiltonian. We report on the current progress of the simulation of oscillating bound states of a giant atom coupled to a waveguide using waveguide arrays as a simulation platform.

Q 62.40 Thu 17:00 Tent

A Photonic-Integrated Quantum-Random Number Generator — •Ömer Bayraktar[1,2], Jonas Pudelko[1,2], Laurenz Ottmann[1,2], Christoph Pacher[3], Winfried Boxleitner[3], and Christoph Marquardt[1,2] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Max Planck Insitute for the Science of Light, Erlangen, Germany — [3]AIT Austrian Institute of Technology GmbH, Center for Digital Safety & Security, Vienna, Austria

Quantum-random number generators (QRNG) are key componenents for quantum-key distribution systems. In addition, compared to conventional true-random number generators, they offer advantages in generation rate and modelling of the entropy source.

We present an experimental QRNG based on balanced homodyne detection of the quantum-optical vacuum state. This QRNG is designed for operations under the restrictive requirements of a 3U CubeSat.

The optical part of the QRNG is monolithically integrated on an Indium-Phosphide photonic-integrated circuit and is placed on a 10x10 cm^2 printed-circuit board accomodating necessary electronics. We show first conclusive results obtained with this system and discuss its operation in space.

Q 62.41 Thu 17:00 Tent

SiV assisted photonic quantum computing — •Konstantin Beck[1], Donika Imeri[1,2], Lasse Irrgang[1,2], Leonie Eggers[1,2], Nick Brinkmann[1,2], Sunil Kumar Mahato[1,2], Rikhav Shah[1], Roman Schnabel[1,2], and Ralf Riedinger[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

Silicon vacancy centers in diamond (SiV) have shown great potential for applications in quantum sensing and quantum communication, due to their optically addressable spin transitions and stability against noise. At temperatures below 300 mK, the SiV has a long-lived spin degree of freedom that enables its use as a qubit for quantum information applications. By efficiently interfacing squeezed photons to the SiV, error-resilient optical Gottesman-Kitaev-Preskill (GKP) states can be created, which enable fault-tolerant continuous variable (CV) quantum computation.

We present a conceptual framework for an efficient telecom squeezed light interface for SiV and the subsequent creation of optical GKP cluster states. Key aspects, such as quantum frequency conversion of squeezed states and spin dependent reflection off the SiV as well as the theoretical implications of using optical GKP qubits in 2D-cluster states for CV quantum computing are highlighted.

Q 62.42 Thu 17:00 Tent

Towards the scale-up of a large-scale quantum computer based on Yb-ions — •Saptarshi Biswas[1], Ivan Boldin[1], Benjamin Bürger[1], Nora Daria Stahr[2,4], Radhika Goyal[2], Patrick Huber[1], Eike Iseke[3,4], Friederike J. Giebel[3,4], Lukas Kilzer[2], Nila Krishnakumar[3,4], Rodolfo Muñoz Rodriguez[1], Tobias Pootz[2], Kais Rejaibi[1], David Stuhrmann[2], Jacob Stupp[2,4], Konstantin Thronberens[3,4], Celeste Torkzaban[2], Pedram Yaghoubi[1], Christian Ospelkaus[2,3,4], and Christof Wunderlich[1] — [1]Department of Physics, School of Science and Technology University of Siegen, 57068 Siegen, Gemany — [2]Gottfried Wilhelm Leibniz Universität, Hannover, Germany — [3]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [4]Laboratory of Nano and Quantum-Engineering, Hannover, Germany

We present the status of a cryogenic (4K) experimental set-up for quantum computing with radio frequency (RF)-controlled trapped ions. It incorporates a novel micro-structured planar Paul trap with integrated micromagnets and we report on the characterization of the first trap generation to be used in this set-up. Also, progress in developing laser cooling techniques for mixed Yb$^+$-Ba$^+$ crystals is reported.

Q 62.43 Thu 17:00 Tent

A cryogenic apparatus for scalable quantum computation with surface ion traps — •Marco Schmauser[1], Marco Valentini[1], Michael Pasquini[1], Jakob Wahl[1,2], Eric Kopp[1], Philipp Schindler[1], Thomas Monz[1], and Rainer Blatt[1] — [1]Universität Innsbruck, Innsbruck, Austria — [2]Infineon Technologies Austria AG, Villach, Austria

Trapped-ion quantum systems are promising candidates for future quantum computing applications. Current trapped ion quantum computing systems in the quantum optics group in Innsbruck are built on a macroscopic linear trap and thus are limited to a maximal number of about 20 ions. Microfabricated surface traps are a popular approach to achieve scalability since they allow for a modular design in which one quantum computing processor consists of many microtraps. We built a cryogenic apparatus to realize fast testing and characterization of such microfabricated traps. The cryostat cools down the trap to a temperature of around 5K within several hours which allows the integration of superconducting materials, for example in the context of superconducting photon detectors, into the trap. Additionally, the integration of the trap via a standardized socket significantly reduces the time to exchange the chips. The setup features 100 DC electrodes and 6 RF electrodes with two independent resonators to enable axial and radial shuttling operations and 21 in-vacuum fibers for all wavelengths of 40Ca+ ions which pave the way for integrating optics into the trap chips. For our first experiments we glue a block of borofloat glass with an inscribed waveguide for 729nm light on top of a surface trap.

Q 62.44 Thu 17:00 Tent

A rack-mounted narrow-band photon pair-source for interfacing with an atomic quantum memory — •Leon Messner[1,2], Mathilde Kakuschke[1,3], Benjamin Maass[2,3], Helen Chrzanowski[4], and Janik Wolters[2,3,1] — [1]Advanced Quantum Light Sources UG, Berlin, Germany — [2]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, Berlin, Germany — [3]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany — [4]Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany

We present the implementation and performance analysis of a portable, rack-mounted photon-pair source for coupling to a ladder-type quantum memory in room-temperature Cesium vapor

The photon source [1] is generating photon-pairs with a bandwidth of 250 MHz, compatible to the linewidth and frequency needs of the atomic storage media. It has high coupling and heralding efficiencies up to 45%.

This allows research into crucial applications and fundamental questions of photon synchronization and shaping using a ladder-type quantum memory in warm alkali vapor [2]. Their fast and noise-free operation make them an ideal component for on-demand storage and retrieval of quantum information in photonic infrastructures.

[1] Mottola, R. et al., Optics Express **28**, 3159-3170 (2020)
[2] Maaß, B. et al., Phys. Rev. Applied **22**, 044050 (2024)

Q 62.45 Thu 17:00 Tent

Studying multifrequency optical lattices for quantum simulation — •Jonathan Bracker[1], Luca Asteria[1,2,5], Marcel Nathanael Kosch[1], Klaus Sengstock[1,2,3], and Christof Weitenberg[1,2,4] — [1]Institut für Quantenphysik, Universität Hamburg, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany — [3]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [4]Department of Physics, TU Dortmund University, 44227 Dortmund, Germany — [5]University of Kyoto, Kyoto, Japan

The multifrequency scheme for optical lattices [1] offers a stable and highly tunable approach for generating complex lattice geometries. Here I present some results of my master's thesis, where I performed numerical simulations of the eigenspectrum and Kapitza-Dirac dynamics for a 5-fold symmetric quasiperiodic optical lattice, revealing localization properties and spectral features. Additional Kapitza-Dirac simulations and preliminary absorption images for a non-separable 3D multifrequency lattice are presented as a first step toward exploring these lattice configurations.

[1] M. Kosch et al., Phys. Rev. Research 4, 043083 (2022)