Q 38: Poster IV

Time: Wednesday 17:00–19:00 Location: KG I Foyer

Q 38.1 Wed 17:00 KG I Foyer

New Magnetically Levitation System for Magnetometry — •Changhao Xu[1,2], Wei Ji[1,2], and Dmitry Budker[1,2,3] — [1]Helmholtz Institute Mainz, Mainz, Germany — [2]Johannes Gutenberg University, Mainz, Germany — [3]Department of Physics, University of California at Berkeley, Berkeley, California 94720-7300, USA

In this work, we attempt to provide a novel magnetometer operable at room temperature. We firstly achieved stable levitation of magnets smaller than 1mm in size at room temperature using diamagnetic levitation techniques. For the levitated magnets, their rotational degrees of freedom are sensitive to external magnetic field strengths with low dissipation. Through the application of optical lever techniques, we have realized high-sensitivity measurements of the rotational dynamics of the levitated magnets. After suppressing factors such as magnetic field noise, air fluctuation, laser-induced thermal damage, and system vibrations, we have currently achieved a sensitivity of 1pT/Hz^1/2 for magnets with a size of 0.5mm.

Q 38.2 Wed 17:00 KG I Foyer

GHZ-bandwidth four-wave mixing in a thermal rubidium vapor using the 6P intermediate state — •Max Mäusezahl[1], Felix Moumtsilis[1], Moritz Seltenreich[1], Jan Reuter[2,3], Haim Nakav[4], Hadiseh Alaeian[5], Harald Kübler[1], Matthias Müller[2], Charles Stuart Adams[6], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Germany — [2]Forschungszentrum Jülich GmbH, PGI-8, Germany — [3]Universität zu Köln, Germany — [4]Weizmann Institute of Science and AMOS, Israel — [5]Departments of Electr. & Computer Engin. and Physics & Astronomy, Purdue University, USA — [6]Department of Physics, Joint Quantum Centre (JQC), Durham University, UK

Fast coherent control of Rydberg excitations is essential for quantum logic gates and on-demand single-photon sources like our concept based on the Rydberg blockade as demonstrated for room-temperature rubidium atoms in a wedged micro-cell. For our improved single-photon source, we employ state-of-the-art 1010 nm pulsed fiber amplifiers to drive a Rydberg excitation via the 6P intermediate state.

Here we report on the current state, technical challenges, time resolved nanosecond pulsed four-wave mixing, GHz Rabi cycling and photon statistics involving the 40S Rydberg state. Using an updated electrical pulse system and detectors we can increase photon generation and detection efficiency, while exploring the effects of the novel excitation scheme experimentally and numerically. The MHz repetition rate and excitation timescales also pave the way towards fast optimal control methods for high fidelity Rydberg logic gates.

Q 38.3 Wed 17:00 KG I Foyer

Gyroscopy with ensemble NV centers in diamond — •Muhib Omar[1,2], Joseph Shaji Rebeirro[1,2], Dmitry Budker[1,2,3], and Arne Wickenbrock[1,2] — [1]Helmholtz-Institut, GSI Helmholtzzentrum für Schwerionenforschung, 55128 Mainz, German — [2]Johannes Gutenberg-Universität Mainz, 55128 Mainz, German — [3]Department of Physics, University of California, Berkeley, California 94720, USA

A rotation sensor protocol utilising the nitrogen nuclear spin in the Nitrogen-Vacancy center (NV) system in diamond is proposed. The nuclear spin state preparation method employed, consisting of a single green laser pulse and a microwave pulse, is to date the shortest pulse sequence employable for gyroscopic sensing using nuclear spins in diamond at arbitrary fields. Field dependence of lower magnetic bias field dynamical nuclear spin polarisation sequences is studied.

Q 38.4 Wed 17:00 KG I Foyer

Magnetometry and Thermometry with NV centers in a seeded optical cavity — •Florian Schall[1], Felix A. Hahl[1], Lukas Lindner[1], Alexander Zaitsev[2], Takeshi Ohshima[3], and Jan Jeske[1] — [1]Fraunhofer Institute for Applied Solid State Physics, Freiburg im Breisgau, Germany — [2]College of Staten Island, New York, USA — [3]National Institutes for Quantum Science and Technology, Gunma, Japan

To measure magnetic fields and temperatures with NV centers in diamond, their spin-dependent fluorescence is usually monitored in an optically detected magnetic resonance (ODMR) measurement. A different approach is the concept of laser threshold magnetometry (LTM), that uses the NV centers as a laser medium. Recently researchers have demonstrated the magnetic field dependence of the stimulated emission from NV centers in a high-finesse optical cavity using a seeding laser. Based on these results we determined the strength and orientation of external magnetic fields created by a permanent magnet. Due to the high finesse of the optical cavity, we achieved high contrasts and output powers in the ODMR measurements. We also investigated the influence of laser and microwave power on diamond temperature. By specifically varying the diamond temperature, we successfully verified the well-known temperature dependence of the zero-field splitting of the NV center. Our results show the first vectorial magnetic field determination with a setup based on LTM. The investigation of the laser-induced temperature changes is highly relevant for a future integration of the setup.

Q 38.5 Wed 17:00 KG I Foyer

Progress towards a fiber-based cold atom source in the meter range — •Marcus Malki, Viet Hoang, Thomas Halfmann, and Thorsten Peters — TU Darmstadt, Darmstadt, Germany

Quantum technologies require controlled interactions with quantum systems that are otherwise isolated from the incoherent environment. In the case of neutral atoms or ions inside a vacuum system this means efficient shielding of the quantum systems from their source, which often is a hot oven. One solution to this problem is a flexible, cold source of neutral atoms.

We here report on our progress towards realizing such a source by implementing a hollow-core fiber (HCF) guide for cold ^{87}Rb atoms in the meter range. The guide is based on an optical dipole trap propagating through the HCF to minimize collisions of the cold atoms with the fiber wall.

We will discuss various considerations regarding the maximum guiding distance, such as background pressure inside the HCF, fiber bending radius, and parametric heating. We will also present first measurements of the HCF loading phase from atoms provided by a dark-line magneto-optical trap and discuss how the number of atoms, their temperature and velocity can be probed inside a HCF.

Q 38.6 Wed 17:00 KG I Foyer

Temperature dependence of charge conversion during NV-center relaxometry — •Isabel Cardoso Barbosa, Jonas Gutsche, Stefan Dix, Dennis Lönard, and Artur Widera — Physics Department and State Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

Temperature-dependent nitrogen-vacancy (NV)-center relaxometry is an established tool to characterize paramagnetic molecules near a sensing diamond. However, charge conversion between the negatively charged NV^- and the neutrally charged NV^0 impedes these pulsed-laser measurements and influences the results for the T_1 time. While the temperature dependence of the NV centers' T_1 time is well-studied, contributions from temperature-dependent charge conversion during the dark time τ may further affect the measurement results. We combine temperature-dependent relaxometry and fluorescence spectroscopy to unravel the temperature dependence of charge conversion in nanodiamond for biologically relevant temperatures. While we observe a decrease of the T_1 time with increasing temperature, charge conversion remains unaffected by the temperature change. These results allow the temperature-dependent performance of T_1 relaxometry without further consideration of temperature dependence of charge conversion.

Q 38.7 Wed 17:00 KG I Foyer

Stable Zerodur based optical system for the MAIUS-2 mission — •Sören Boles[1], Moritz Mihm[1], André Wenzlawski[1], Ortwin Hellmig[2], Klaus Sengstock[2], Patrick Windpassinger[1], and the MAIUS Team[1,2,3,4,5,6] — [1]Johannes Gutenberg Universität Mainz — [2]ILP, Universität Hamburg — [3]Institut für Physik, HU-Berlin — [4]IQO, Leibniz Universität Hannover — [5]ZARM, Universität Bremen — [6]FBH, Berlin

Launched in December 2023, the MAIUS-2 mission investigates BEC-mixtures of Rb and K in microgravity environment on a sounding rocket flight. To assure stable performance of the optical system under the harsh launch conditions, fiber-coupled optical benches were

manufactured based on the glass ceramic Zerodur, a material which excels in having a very low coefficient of thermal expansion (CTE), as well as a high mechanical strength. Successful implementation of this optical technology was shown in various missions, such as FOKUS, KALEXUS, as well as its predecessor MAIUS-1.
MAIUS-2 represents new challenges to the optical technology, since light to manipulate both atomic species has to be intensity controlled, pulse-shaped and fiber-coupled to realize the experimental goals.
In this submission, we will present the performance of the Zerodur optical technology during the launch and flight of the MAIUS-2 mission.
MAIUS is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economic Affairs and Climate Action (BMWK) under grant numbers 50WP1433 & 50WP2103.

Q 38.8 Wed 17:00 KG I Foyer

(Near) zero-field cross-relaxation features for diamond magnetometry — •Omkar Dhungel[1,2], Till Lenz[1,2], Mariusz Mrózek[3], Muhib Omar[1,2], Joseph Shaji Rebeirro[1,2], Wojciech Gawlik[3], Adam Wojciechowski[3], Viktor Ivady[4,5,6], Adam Gali[7,8], Arne Wickenbrock[1,2], and Dmitry Budker[1,2,9] — [1]Helmholtz-Institut Mainz, GSI, 55128 Mainz, Germany — [2]JGU Mainz, 55128 Mainz, Germany — [3]Jagiellonian University, Faculty of Physics, Astronomy and Applied Computer Science, Lojasiewicza St. 11, 30-348 Krakow, Poland — [4]Department of Physics of Complex Systems, ELTE Eötvös Loránd University, Egyetem tér 1-3, H-1053 Budapest, Hungary — [5]MTA-ELTE Lendület *Momentum* NewQubit Research Group, Pázmány Péter, Sétány 1/A, Budapest,1117, Hungary — [6]Department of Physics, Chemistry and Biology, Linköping University, 581 83 Linköping, Sweden — [7]Wigner Research Centre for Physics, P.O. Box 49, H-1525 Budapest, Hungary — [8]BUTE, Institute of Physics, Department of Atomic Physics, Müegyetem rakpart 3., 1111 Budapest, Hungary — [9]Department of Physics, UC, Berkeley, California 94720-300, US

We study zero-field cross-relaxation features of negatively charged nitrogen-vacancy (NV) center ensembles in diamond. This feature holds promise for magnetometry applications where either the microwaves or the bias magnetic field used in conventional NV center magnetometry disturb the system under study; for example, the study of high-temperature superconductors, zero- to ultralow-field (ZULF) NMR, investigation of biological samples, and magnetic materials.

Q 38.9 Wed 17:00 KG I Foyer

Ion trap chips on dielectric substrates for double-well coupling experiments — •Michael D.J. Pfeifer[1,2], Simon Schey[1,3], Matthias Dietl[1,2], Fabian Anmasser[1,2], Jakob Wahl[1,2], Marco Valentini[2], Martin van Mourik[2], Thomas Monz[2], Fabian Laurent[1], Clemens Rössler[1], Yves Colombe[1], and Philipp Schindler[2] — [1]Infineon Technologies Austria AG, Villach, Austria — [2]University of Innsbruck, Innsbruck, Austria — [3]Stockholm University, Stockholm, Sweden

We report on surface ion trap chips, industrially fabricated at Infineon Technologies [1,2], that are capable to generate a two-well potential for trapping ions. The chips are designed for investigating rf shuttling in the large separation and in the coupling regimes as element of a scalable architecture [1]. The optimization of the design parameters of a surface ion trap in the rf coupling regime with optimal ion height and ion-ion distance is discussed.

The dielectric substrates Fused Silica and Sapphire are used in the fabrication of the chips. The status of the microfabrication on these materials is discussed, with a focus on optical and electric properties, as well as on wafer bow.

[1] Ph. Holz, S. Auchter et al., Adv. Quantum Technol. 3, 2000031 (2020)

[2] S. Auchter, C. Axline et al., Quantum Sci. Technol. 7, 035015 (2022)

Q 38.10 Wed 17:00 KG I Foyer

Microscopy Setup for Optical Measurements of Distances between Nanodiamonds and Microwave-Antennas — •Oliver Beiersdorf, Stefan Dix, Dennis Lönard, Isabel Barbosa, and Artur Widera — Department of Physics and State Research Center OPTIMAS, University of Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

Due to their properties, negatively charged nitrogen-vacancy (NV) centers in nanodiamonds are well-known in the field of magnetometry. In these quantum systems, spin transitions can be induced by resonant microwave pulses and measured by fluorescence after laser excitation.

In this work, a reflected light microscopy setup for nanodiamonds was built, including illumination and excitation of a sample positionable with an accuracy of about 100 nm, a camera setup, and a fluorescence detection unit. It further allows to freely position optical fibers over the sample with an accuracy of about 1 μm.

In this way, we want to quantify the dependence of the rabi-oscillations of NV centers on the distance of a fiber-based endoscope with a silver direct-laser-written structure for microwave emission next to a fiber facet that can be used for excitation. By successfully determining this dependence, we aim to validate the suitability of NV diamonds as quantum sensors not only for magnetometry but also for distance determination, ultimately enabling multifunctional NV-based sensors.

Q 38.11 Wed 17:00 KG I Foyer

Real-world NV-center vector magnetometry of a 3D coil system — •Dennis Lönard, Stefan Dix, Isabel Barbosa, and Artur Widera — Physics Department and State Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

The nitrogen-vacancy (NV) color center in diamond is an essential platform for magnetic field sensing for technical and biological applications. One major advantage is that the spin state of the NV-center can be read out optically via fluorescence. Observing the Zeeman-splitting of four independent NV axes in one diamond then enables full vectorial magnetometry. The signal detection of the NV fluorescence can be substantially improved with lock-in amplification. However, discussions of magnetic field sensitivity are often limited to artificially engineered lab conditions. Technical difficulties that arise when NV magnetometry is to be performed in unknown magnetic fields are often disregarded.

Here, we present a real-world measurement of the vector magnetic field of a 3D coil system, used in a quantum gases experiment. Our sensor exhibits magnetic field sensitivities down to 200nT/rt(Hz) with bandwidths of up to 100Hz. Thus showing the improvements NV center magnetometry can deliver over conventional instruments like Hall-sensors. Signal-to-Noise ratio and magnetic field sensitivity can be further improved with balanced photodiode detection techniques.

Q 38.12 Wed 17:00 KG I Foyer

Optimizing efficiencies in time-multiplexed photonic quantum walks — •Philip Held, Vincent Borlisch, Federico Pegoraro, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute of Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Germany

Quantum walks function as essential means to implement quantum simulators, allowing one to study complex quantum processes that often cannot be directly accessed in the laboratory. Time-multiplexed photonic quantum walks offer the possibility to build easily scalable systems. Here the position space of the walk is mapped to temporal bins and physical elements of the setup are used time and again. Experimentally this is implemented by realizing a looped structure, such that each step is implemented by one roundtrip through the setup. Thus, the overall losses - wich constitute the main limitation of the system - are mainly determined by the roundtrip losses that scale exponentially with the step number. In this contribution, we present a new scheme to build time-multiplexed photonic quantum walks. We were able to reduce the number of required optical components and improve the spatial mode matching of the optical paths. The new setup architecture features a smaller, compact footprint, higher long-term stability, and a reduction of losses by more than 25% compared to the original version. We now achieve a round-trip efficiency of 86%, which reduces the measurement time by an order of magnitude for a 20-step two-photon quantum walk.

Q 38.13 Wed 17:00 KG I Foyer

Nonlinear light-matter interaction based on integrated waveguides immersed in hot atomic vapor — •Annika Belz[1], Robin Klöpfer[1], Benyamin Shnirman[1,2], Xiaoyu Cheng[1], Harald Kübler[1], Charles Stuart Adams[3], Hadiseh Alaeian[4], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology (IQST), Universität Stuttgart, Germany — [2]Institut für Mikroelektronik Stuttgart (IMS-Chips), Stuttgart, Germany — [3]Department of Physics, Joint Quantum Centre (JQC) Durham-Newcastle, Durham, United Kingdom — [4]Departments of Electrical & Computer Engineering and Physics & Astronomy, Purdue University, West Lafayette, USA

The combination of thermal atomic vapor with nano-photonic structures provides a unique platform for the manipulation of atom-photon

and light induced atom-atom interactions and can exhibit large optical non-linearities, even at the single photon level.

We can further enhance these non-linearities by using slot waveguides in which we observe repulsive interactions of the atoms within the slot via an enlarged Purcell factor. Thereby we generate a medium that reaches already in this specific setting a nonlinearity on the few photon level. In order to verify the nature of the non-linearity in more detail we plan to incorporate an integrated Mach-Zehnder interferometer to access also the non-linear phase shift.

Furthermore, we present first measurements of the phase shift in a thermal atomic vapor using a fiber coupled Michelson interferometer.

Q 38.14 Wed 17:00 KG I Foyer

A miniaturized and integrated fiber-based magnetic field sensor — •Stefan Dix, Dennis Lönard, Isabel Cardoso Barbosa, Jonas Gutsche, and Artur Widera — Physics Department and State Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

The nitrogen-vacancy (NV) center is a crucial element in measuring precise magnetic fields while also retrieving temperature information. Possible applications for this sensor range from medical surgery over the analysis of magnetic samples to current monitoring of today's electric vehicles. While other concepts for integrated sensors have been shown, ongoing miniaturization requires ever smaller yet more robust sensing devices. In this work, we developed a versatile and robust sensor platform for macroscopic handling while maintaining a compact size and including wires and optical fibers on a platform diameter of 1.25 mm. Furthermore, we use direct laser writing to fixate and couple a 15 μm-sized diamond containing NV centers to one optical fiber and create a waveguide structure between another optical fiber to excite the NV center. Thus, we separate beam paths for excitation and detection to enhance the sensitivity. Necessary antenna structures are created on the tip of an optical fiber using a silver direct laser writing process. We test our device by probing the field distribution of a magnetic-coil system with high spatial and magnetic field resolution. Our results point towards a sub-millimeter, integrated sensor for high spatial resolution vector magnetometry with a large bandwidth.

Q 38.15 Wed 17:00 KG I Foyer

Fabricating high-finesse fiber Fabry-Perot cavities for quantum simulation — •Constantin Grave, Isabelle Safa, Marvin Holten, and Julian Leonard — TU Wien - Atominstitut, Stadionallee 2, 1020 Wien, Österreich

Fiber Fabry-Perot cavities (FFPCs) are used in a wide spectrum of technical and scientific applications ranging from cavity quantum electrodynamics and fiber-coupled single-photon sources to new scanning microscopy techniques. We realize a highly automated fabrication facility to manufacture curved mirrors on the end-facets of optical fibers. While the curvature is shaped with a CO2 laser, the coating for the reflectivity is applied externally. In our setup a Mireau objective using white light interferometry is included, allowing us to measure the shape of the mirror during production and enabling iterative optimisation of the geometry. We expect this approach to result in small yet open FFPCs with favorable scaling properties, small mode volumes as well as high finesses. This combination of features is advantageous for the construction of compact and robust quantum-enabled devices like the currently build setup of our group, that uses an tweezer-loaded array of neutral atoms inside a FFPC.

Q 38.16 Wed 17:00 KG I Foyer

Industrial fabrication of surface ion-traps with integrated optics — •Jakob Wahl[1,2], Alexander Zesar[1], Klemens Schüppert[1], Clemens Rössler[1], Philip Schindler[2], and Christian Roos[2] — [1]Infineon Technologies Austria — [2]University of Innsbruck

Trapped ions have shown great promise as a platform for quantum computing, with long coherence time, high fidelity quantum logic gates, and the successful implementation of quantum algorithms. However, to develop trapped-ion based quantum computers from laboratory setups to practical devices for solving real-world problems, the number of controllable qubits must be increased while improving error rates. One of the major challenges for scaling trapped-ion quantum computers is the need to switch from free space to integrated optics, to achieve lower drift and vibrations of light relative to the ion, and therefore more stable and scalable ion-addressing.

At Infineon and the University of Innsbruck, we are working on the integration of optical elements in surface ion traps, which are fabricated in industrial semiconductor facilities at Infineon. We use femtosecond-laser written waveguides to guide light in a glass-block that is manufactured on the chip's surface in wafer-level processes. The integrated waveguides eliminate vibrations between optics and the ion, and therefore reduce intensity fluctuations of the laser light at the position of the ion. Moreover, integrated waveguides can enable complex light routing to multiple trapping sites and make quantum information processors more robust and more parallelizable.

Q 38.17 Wed 17:00 KG I Foyer

Edge Machine-Learning assisted Magnetometer Based on NV-Ensembles in Diamond — •Jonas Homrighausen[1], Ludwig Horsthemke[2], Jens Pogorzelski[2], Sarah Trinschek[1], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, University of Applied Sciences, Münster — [2]Department of Electrical Engineering and Computer Science

In the field of quantum sensing, particularly in magnetometry, the nitrogen-vacancy (NV) center in diamond stands out as a promising sensor material. It offers high sensitivity, exceptional spatial resolution, and wide bandwidth at room temperature, making it an ideal candidate for miniaturization and integration due to its solid-state host crystal. However, the real-time tracking of magnetic field strengths using optically detected magnetic resonance (ODMR) poses challenges, requiring sophisticated equipment such as multi-channel frequency modulated RF generators and lock-in techniques. Additionally, accurately calculating magnetic field magnitudes from transition frequencies requires various parameters like crystal orientation and internal strain parameters. To address these challenges, we propose a machine-learning assisted approach leveraging an ESP32 microcontroller as the central control and acquisition unit [1]. By performing inference on a pre-trained artificial neural network using data collected from a fiber-coupled NV ensemble, we obtain the local magnetic field magnitude at the fiber tip. By using off-the-shelf components, we present a low-cost, low-power standalone sensor device that can easily made portable.

[1] J. Homrighausen et al. (2023). Sensors 23(3), 1119.

Q 38.18 Wed 17:00 KG I Foyer

Rydberg Atom-based RF Sensors: E-field amplitude and phase-sensitive detection — •Clara Roth, Matthias Schmidt, Lara Metzger, Stephanie Bohaichuk, Chang Liu, Florian Christaller, Vijin Venu, Harald Kübler, and James Shaffer — Quantum Valley Ideas Laboratory, Waterloo, Canada, ON

We present theoretical work aimed at understanding radio frequency phase and amplitude measurement using all-optical, atom-based electric field sensors. Atom-based radio frequency field sensors have a number of applications in communications, radar and test and measurement where both phase and amplitude information are important. We apply the weak probe approximation to the Lindblad-master equation and find analytic expressions for the density matrix in steady state in several level schemes up to 5 levels where a closed loop is formed. We focus especially on the absorption coefficient and the populations of Rydberg states. With these expressions, we gain a deeper understanding of the multi-photon interference and how this applies to phase and amplitude readout in atom-based radio frequency sensors.

Q 38.19 Wed 17:00 KG I Foyer

Low Cost Prototyping and Teaching Platform for Quantum Sensing using NV Centers — •Marina Peters[1], Jan Stegemann[1], Ludwig Horsthemke[2], Matthias Hollmann[1], Nils Haverkamp[3], Stefan Heusler[3], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster University of Applied Sciences, Germany — [2]Department of Electrical Engineering and Computer Science, FH Münster University of Applied Sciences, Germany — [3]Institute of Physics Education Research, University of Münster

With the growing importance of quantum technology in industry and research, the need for affordable, flexible and robust laboratory experiments for prototyping and university studies is increasing. With this modular, 3D-printed, low-cost (< €250) open source experiment platform [1,2], students can learn about the principles of quantum systems using the example of NV centers in diamond. The optical components are mounted in 3D-printed cubes [3,4] that can be freely arranged on a grid. The platform presented enables experiments on magnetometry using optically detected magnetic resonance (ODMR) and lowers the threshold to access modern quantum technology. [1] www.O3Q.de [2] Stegemann, J. et al. European Journal of Physics 44 (2023), [3] Diederich, B. et al. Nature Communications11, 5979 (2020)

[4] Haverkamp, N. et al. Physics Education 57 025019 (2022)

Q 38.20 Wed 17:00 KG I Foyer

Coherent control of ion motion via Rydberg excitation — •Marion Mallweger[1], Andre Cidrim[2], Harry Parke[1], Natalia Kuk[1], Robin Thomm[1], Chi Zhang[1], and Markus Hennrich[1] — [1]Stockholm University, Stockholm, Sweden — [2]Universidade Federal de São Carlos, São Carlos, Brazil

Trapped Rydberg ions are a novel approach to quantum information processing, combining qubit rotations in the ions' ground states with entanglement operations via Rydberg interaction. In the experiments presented here a trapped strontium ion was excited from the metastable 4D to Rydberg states. While for the ground state of the ion, the polarizability is negligible, for Rydberg ions it increases as $\sim n^7$. Thus, the high polarizability of the Rydberg state with respect to the ground state leads to a displaced trapping potential during the Rydberg excitation if the ion experiences an offset electric field. We explore how this trapping field displacement can be employed for coherent control of the ions' motion. We investigate this effect by performing coherent excitation of the ion to the Rydberg state by using stimulated Raman adiabatic passage (STIRAP). Repeated transitions between the ground and the Rydberg states enhances the effect of the ion displacement due to the change in trapping potential. This can be used to induce a geometric phase accumulation via the ion motion. This excitation of motional modes via Rydberg excitation and the generation of geometrical phases could be utilized for realizing a fast quantum phase gate between multiple ions.

Q 38.21 Wed 17:00 KG I Foyer

QKD with atom photon entanglement over an urban fiber link — •Jonas Meiers, Christian Haen, Max Bergerhoff, Stephan Kucera, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken

Quantum cryptographic protocols offer physical security through nocloning or entanglement. Following the entanglement-based quantum key distribution protocol of [1], we present our implementation of atomphoton entanglement-based quantum key distribution over a telecom fiber in a metropolitan network. The protocol requires four atomic bases as well as two photonic bases and allows us to create a quantum key with security verification via the Bell parameter. We employ the polarization entanglement between a single trapped $^{40}Ca^{+}$-ion and an emitted photon at 854 nm according to [2], generated via the $P_{3/2} \rightarrow D_{5/2}$ transition. The photon is frequency-converted into the telecom band and transmitted via a 15-km long urban dark fiber across Saarbrücken. The fiber has been characterized and stabilized for the transmission of polarization-encoded qubits. Following the implementation we discuss how well the experimental data agree with the predictions from the theoretical protocol.

[1] R. Schwonnek et al., Nat. Commun. 12, 2880 (2021)
[2] M. Bock et al., Nat. Commun. 9, 1998 (2018)

Q 38.22 Wed 17:00 KG I Foyer

A Squeezed Light Interface for Silicon Vacancy Centers in Diamond — •Konstantin Beck[1], Donika Imeri[1,2], Mara Brinkmann[1], Timo Eikelmann[1], Lasse Jens Irrgang[1], Lennart Manthey[1], 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. Integrating the properties of SiV centers with the accessibility of a fiber network operating at telecom wavelengths can enable efficient long-distance quantum communication.

We present a conceptual framework of an optical interface where we couple squeezed photons to the silicon vacancy qubit and create Gottesman-Kitaev-Preskill (GKP) states, known for their significance in error resilient quantum communication protocols. We discuss the theoretical aspects of GKP state creation as well as the experimental setup. Key aspects such as the squeezed state preparation, the diamond nanophotonic cavities hosting SiV centers and the overall architecture of the experiment are highlighted.

Q 38.23 Wed 17:00 KG I Foyer

Fast, efficient and lossless measurement of atom-photon entanglement — •Gianvito Chiarella, Tobias Frank, Pau Farrera, and Gerhard Rempe — Max Planck Institute for Quantum Optics, Garching bei München, Germany

Efficient quantum light-matter interfaces are crucial for the development of quantum networks, which allow the generation, distribution and storage of quantum states over remote locations. Two important capabilities of a quantum network node are the efficient generation of entanglement between a stationary and a flying qubit and the measurement of the stationary qubit in a fast and efficient way. Moreover it is also important that the stationary qubit is usable after its measurement. Even though these features have been shown separately in previous works, achieving them simultaneously remains a challenge. Here we report about a quantum network node composed of a single Rb87 atom coupled to two crossed fiber resonators, one mediating the generation of a photonic qubit entangled with the atom, and the other collecting fluorescence photons for atomic state measurement. We achieve an entanglement generation efficiency of 44%, and we measure an atomic state in 7.5us with a fidelity of 98.5%. The implementation of such a node in a quantum network would be beneficial for quantum communication protocols that involve the distribution of entanglement between nodes as a resource.

Q 38.24 Wed 17:00 KG I Foyer

Active Polarization Modulation of Passive Entangled Photon Pair Sources — •Sabine Häussler[1], Philippe Ancsin[1], Meritxell Cabrejo-Ponce[1,2], Rodrigo Gómez[1,2], and Fabian Steinlechner[1,2] — [1]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Straße 7, 07745 Jena, Germany — [2]Friedrich Schiller University, Institute of Applied Photonics, Abbe Center of Photonics, Albert-Einstein-Str. 12, 07745 Jena, Germany

Entangled photon pair sources (EPS) are typically optimized to produce a single well-defined quantum state. While such passive sources are highly suitable for quantum key distribution (QKD), more advanced cryptographic protocols with multiple parties, such as quantum secret sharing (QSS), demand more flexible sources that incorporate active modulation. In our previous research, we have examined the feasibility for multi-partite QKD using an EPS with active state modulation. There, the EPS is based on a complete in-fiber Sagnac interferometer with a cascade of second-harmonic generation and downconversion in two nonlinear waveguides. This setup offers high brightness, phase stability, and high-speed active modulation. However, in this configuration, Raman noise in fibers represents an issue that limits performance. To overcome this restriction, the active modulation is moved outside the Sagnac loop to the pump preparation stage. This active system for polarization encoding is combined with a passive EPS, giving altogether a better performing system for flexible applications in QKD. The system was characterized regarding its applicability as a reconfigurable quantum network for QSS.

Q 38.25 Wed 17:00 KG I Foyer

Time-Bin QKD with Wavelength-Division Multiplexing — •Niklas Humberg, Alejandro Sánchez-Postigo, and Carsten Schuck — Departement for Quantum Technology, Münster, Germany

When doing Quantum Key Distribution, there are several different approaches to increase the secret key rate of a quantum channel. One possibility is Wavelength-Division Multiplexing (WDM), where photons of several different wavelengths are sent simultaneously in parallel over the same channel. These time-bin encoded qubits are generated by a narrow-band laser with adjustable wavelength in combination with electro-optic modulators for pulse generation. After transmission through a quantum channel with up to 90 km length, the qubits are demultiplexed and analyzed in the time domain using an 8-channel silicon nitride-on-insulator photonic integrated circuit. We use Mach-Zehnder interferometers with a 200 ps on-chip delay line to measure in complementary bases and enable a maximal key generation rate of up to 2.5 Gbit/s employing NbTiN superconducting nanowire single-photon detectors (SNSPDs) with high timing accuracy. We present simulation results, the QKD setup, and first measurements.

Q 38.26 Wed 17:00 KG I Foyer

Low Noise Quantum Frequency Conversion of SnV-Resonant Photons to the Telecom C-Band — •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, that store, process and distribute quantum information [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 for SnV-resonant photons at 619 nm. Scaling this to large networks requires a shared frequency reference frame to ensure, e.g, the indistinguishability of two converted photons from different nodes, when performing a Bell state measurement.

We here present a two-stage low noise scheme for quantum frequency conversion of SnV-resonant photons to the telecom C-band 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 the conversion efficiency, conversion-induced noise count rates, and initial results on the frequency stabilization of the mixing laser.

[1] J. Görlitz et al., npj Quant.Inf. 8, 45 (2022).
[2] R. Debroux et al., Phys. Rev. X 11, 041041 (2021).
[3] M. Schäfer et al., Adv Quantum Technol. 2300228 (2023).

Q 38.27 Wed 17:00 KG I Foyer

Polarization-Preserving Quantum Frequency Conversion of $^{40}Ca^+$-Resonant Photons to the Telecom C-Band — •Tobias Bauer, David Lindler, and Christoph Becher — Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken

In quantum communication networks information is stored in internal states of quantum nodes, which can be realized e.g. in trapped ions like $^{40}Ca^+$ [1] or SnV color centers in diamond [2]. By transferring the states onto flying quantum bits, i.e. photons, it is possible to exchange information between these nodes over long distances via optical fiber links. Utilizing quantum frequency conversion to a common target wavelength enables the entanglement of dissimiliar quantum memories and drastically reduces fiber attenuation by choosing a target wavelength in a low loss telecom band.

We present a high-efficiency, rack-integrated quantum frequency converter for polarization-preserving conversion of $^{40}Ca^+$-resonant photons to the telecom C-band. This converter is highly suited for real-world applications in urban area fiber networks, e.g. photonic entanglement distribution [3] or creation of remote entanglement of atomic systems. We will also show first progress towards the entanglement of a $^{40}Ca^+$-ion with a SnV center by stabilizing the mixing lasers for both conversion processes to a common frequency reference.

[1] C. Kurz et al., Phys. Rev. A. 93, 062348 (2016)
[2] J. Görlitz et al., npj Quant.Inf. 8, 45 (2022)
[3] E. Arenskötter, T. Bauer et al., npj Quantum Inf 9, 34 (2023)

Q 38.28 Wed 17:00 KG I Foyer

Coherent excitation of tin vacancy centres in diamond using a cross-polarization excitation scheme — •Dennis Herrmann, Robert Morsch, and Christoph Becher — Fachrichtung 7.2, Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany

In recent years the tin vacancy centre (SnV) in diamond has raised interest in the QIP community as it offers bright and pure single photon emission into lifetime limited optical transitions combined with long spin dephasing times on the order of $T_2^* \sim 5\mu s$ [1,2,3]. The coherent control of qubits and the generation of spin-photon entanglement typically requires resonantly driving optical transitions of the SnV centre. A spectral separation of excitation and emission wavelengths is highly desirable to discriminate the strong driving against single emitted photons. However, in the level scheme of the SnV centre we find that the large ground state splitting leads to a fast population decay from the upper to the lower orbital ground state making it necessary to excite and read out on the same optical transition. Here we deploy a homebuilt cross-polarisation confocal microscopy setup as demonstrated for semiconductor systems [4,5]. Offering polarisation extinction ratios of up to 10^7 it is enabling the strong polarisation selective suppression of laser light with respect to orthogonally polarised photons emitted on the same optical transition. Using short excitation pulses of below $250ps$ we furthermore demonstrate coherent Rabi-Oscillations.

1. New J. Phys. 22, 013048 (2020). 2. npj Quantum Inf 8, 45 (2022). 3. Phys. Rev. X 11, 041041 (2021). 4. Phys. Rev. X 11, 021007 (2021). 5. Rev. Sci. Instrum. 84, 073905 (2013).

Q 38.29 Wed 17:00 KG I Foyer

Indistinguishable single photons from negatively charged tin-vacancy centres in diamond — •R. Morsch[1], D. Herrmann[1], J. Goerlitz[1], B. Kambs[1], P. Fuchs[1], P.-O. Colard[2], M. Markham[2], and C. Becher[1] — [1]Fachrichtung 7.2, Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany — [2]Element Six Global Innovation Centre, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire, X11 0QR, UK

Within the field of quantum information processing (QIP) numerous schemes demand long-lived, stationary qubits, that can be controlled coherently and read out optically. Furthermore, a linear optics quantum computer inherently relies on the emission of single indistinguishable photons. The negatively charged tin-vacancy centre (SnV-) in diamond has made its mark as a promising candidate for these applications. Individually addressable spins with long coherence times as well as bright emission of single, close-to-transform limited photons render it a good light-matter interface. Moreover, recent studies point towards high achievable indistinguishabilities upon resonant excitation. Here we present our work on different excitation schemes for the generation of single indistinguishable photons emitted by SnV-centres: In off-resonant excitation we find the indistinguishability of the single photons to be limited due to the high excitation powers needed. We further evaluate different approaches for excitation within the SnV multi-level scheme and discuss their limitations. Eventually we report on the state of experiments on emission of indistinguishable single photons upon resonant excitation in a homebuilt cross-polarization setup.

Q 38.30 Wed 17:00 KG I Foyer

Highly-automated 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

Quantum frequency conversion of single photons to low-loss telecom bands is one of the key enabling technologies to distribute entanglement in fiber-linked quantum networks. However, in order to make this technology viable for real-world applications, quantum frequency converters must ensure robust 24/7 operation even outside of laboratory conditions and without human intervention.

Here, we investigate the employment of automation technology in quantum frequency converters aiming to increase robustness, stability and functionality. In particular automatic beam alignment and beam position stabilization are used to ensure long-time stable operation even under varying ambient conditions. We aim to automate a conversion process, where in two separate PPLN waveguides photons resonant with tin-vacancy (SnV) centers in diamond are first converted to an intermediate wavelength and then to the telecom C-band. Such a two-stage scheme was recently shown to successfully circumvent pump-induced noise for the conversion of single photons from silicon-vacancy centers to diamond [1].

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

Q 38.31 Wed 17:00 KG I Foyer

A portable warm vapour quantum memory — •Martin Jutisz[1], Alexander Erl[2,3], Elisa Da Ros[1], Luisa Esguerra[3,2], Janik Wolters[3,2], Mustafa Gündoğan[1], and Markus Krutzik[1,4] — [1]Humboldt-Universität zu Berlin, Berlin, Germany — [2]Technische Universität Berlin, Berlin, Germany — [3]Deutsches Zentrum für Luft- und Raumfahrt, Berlin, Germany — [4]Ferdinand-Braun-Institut (FBH), Berlin, Germany

Warm vapor quantum memories have seen significant progress in terms of efficiency and storage time in recent years. Their low complexity makes them a promising candidate for operation in non-lab environments including space-based applications. As a necessary element of quantum repeaters, memories operating in space could advance global quantum communication networks [1].

We will present the implementation and performance of a portable rack-mounted stand alone system, that includes also the laser system and control electronics. The optical memory is based on long-lived hyperfine ground states of Cesium which are connected to an excited state via the D_1 line at 895 nm in a lambda-configuration. The stability of the memory efficiency and fidelity is demonstrated at single photon level. Different methods to micro integrate this platform are also being investigated.

This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number 50RP2090 & 50WM2347.

[1] M. Gündoğan et. al., npj Quantum Information 7, 128 (2021)

Q 38.32 Wed 17:00 KG I Foyer

Processing of Tapered Fibres with Concave End Facets for Quantum Networks — •Lasse Jens Irrgang[1], Georgia Eirini Mandopoulou[1,3], Timo Eikelmann[1], Mara Brinkmann[1], Tuncay Ulas[1], Sunil Kumar Mahato[1,2], Donika Imeri[1,2], Rikhav Shah[1], 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 — [3]Department of Physics, Harvard University, Cambridge, MA 02138, USA

A key aspect in the creation of quantum networks for quantum communication based on trapped ions or vacancy centres is the interface between photons travelling in fibres and the qubit. For an efficient connection, fibres need to be processed to fit the application. We present a set-up based on laser ablation which allows for precise machining of fibres and presents an alternative to the current technique of etching with hydrofluoric acid. Specifically, we produce concave end facets and tapered profiles with desired properties. The applications include low noise microcavities in QED-based interfaces to trapped ions or Rydberg atoms. Fibres exhibiting only the tapered profile can also be used for a connection to silicon vacancy centres in diamond.

Q 38.33 Wed 17:00 KG I Foyer

Robust Dynamical Decoupling Driven by Pulses with Field Inhomogeneities in Pr:YSO — •Niklas Stewen, Markus Stabel, and Thomas Halfmann — Technische Univeristät Darmstadt, Germany

We present a demonstration experiment in which we compare the robustness of state-of-the-art composite pulse (CP) sequences for dynamical decoupling with regard to typically unavoidable inhomogeneities in the driving radiofrequency (RF) pulses. To systematically vary and characterize the field inhomogeneity, we modify the winding number of our driving RF coils, and, using an orthogonal addressing of the crystal, perform a spatially resolved measurement of the Rabi frequency distribution in 3D. We quantify the performance of CP sequences at different inhomogeneities by measuring the coherence time of EIT light storage in a Pr:YSO crystal. We find that already for rather homogeneous driving fields, CP sequences and in particular the universal robust (UR) family of sequences provide a large improvement compared to the standard CPMG sequence. This advantage further increases with the field inhomogeneity.

Q 38.34 Wed 17:00 KG I Foyer

Towards Photonically Connected Quantum Nuclear Microprocessors — •Donika Imeri[1,2], Timo Eikelmann[1], Mara Brinkmann[1], Lennart Manthey[1], Rikhav Shah[1], Lasse Jens Irrgang[1], Konstantin Beck[1], 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-vacancy (SiV) color centers in diamond are promising candidates for enhancing quantum communication systems. SiVs exhibit advantageous characteristics as solid-state emitters with an effective optical interface and protective inversion symmetry. This setup enhances the entanglement generation between spin qubits and photonic qubits, which is a crucial step toward building scalable quantum communication networks. Key challenges in achieving coherent interactions between nuclear spins and SiV are ultra-low temperatures and strong currents that generate radio-frequency fields. Here, we present a platform integrating nuclear magnetic resonance coils with nanophotonic structures designed to operate at millikelvin temperatures, thus paving the way for advancements in quantum networks using SiV-based systems.

Q 38.35 Wed 17:00 KG I Foyer

A Protocol for Multiplexed Entanglement Generation with Distinguishable Telecom Emitters — •Fabian Salamon[1,2], Olivier Kuijpers[1,2], Adrian Holzäpfel[1,2], and Andreas Reiserer[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Technische Universität München, TUM School of Natural Sciences, James-Franck-Straße 1, 85748 Garching, Germany

Second-long spin coherence times and emission in the minimal-loss telecommunication window make erbium dopants in solid-state host crystals a particularly attractive candidate for future quantum network applications [1].

Spectral diffusion has so far prevented the generation of entanglement between these erbium emitters, since most entanglement protocols require the emission of indistinguishable photons. Here, we present a protocol that bypasses this constraint: Upon reflection on a strongly coupled atom-cavity system, a high-fidelity controlled-Z gate can be applied to a photon [2]. Since the bandwidth of this gate is larger than the spectral diffusion, entanglement can be generated between two distinguishable erbium emitters.

The envisioned hybrid platform combines a large-scale multiplexing capability with insensitivity to spectral diffusion. This could enable entanglement generation over hundred kilometres of optical fiber at unprecedented rates.

[1] A. Reiserer, Rev. Mod. Phys. 94, 041003 (2022). [2] A. Reiserer, N. Kalb, G. Rempe & S. Ritter, Nature 508(7495), 237-240 (2014).

Q 38.36 Wed 17:00 KG I Foyer

Exploring Germanium-Vacancy Centers in Diamond Cavities for a Quantum Repeater Module — •Prithvi Gundlapalli, Katharina Senkalla, Lev Kazak, Philipp Vetter, Stefan Dietel, and Fedor Jelezko — Universität Ulm

Diamond photonic cavities present a compelling architectural framework for effectively addressing individual spins associated with diamond color centers, thereby enabling the scalability of diverse quantum applications in sensing, computing, and networking. An essential prerequisite for quantum networks involves entangling color centers separated over considerable distances, necessitating the employment of quantum repeaters due to the unreliable transmission of flying qubits over such distances. Notably, group IV defects like Ge, Sn, and Pb vacancy centers within diamond exhibit promising attributes such as efficient light-matter interfaces as well as long coherence times, which are conducive to serving as candidates for quantum repeaters. We present our progress on the development of diamond photonic cavities integrated with Germanium vacancy centers (GeV) as well as simulation results that allows for efficiently building quantum registers. These will ultimately be used to develop a quantum repeater module.

Q 38.37 Wed 17:00 KG I Foyer

Titel — •Leon Messner[1], Helen Chrzanowski[1], and Janik Wolters[1,2] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, Berlin, Germany — [2]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany

We present first results and future prospects for a photon-pair source based on spontaneous parametric down-conversion (SPDC) in a periodically poled monolithic KTP crystal cavity[1]. By proper engineering of the cavity parameters and phase-matching, it is possible to tune the source for interfacing with atomic systems and particularly with quantum memories.

By putting the cavity end mirrors directly on the non-linear crystal we have build a photon-pair source that is set to a dedicated signal and idler wavelength of 895 nm with a bandwidth of 250 MHz and a cavity finesse of 90 while retaining a tuneability of 20 GHz. The source emits photon pairs at a rate of 40 kcts/s with an heralding efficiency of 38%, limited by the current choice of collimation optics.

We plan on interfacing our source with a warm vapor EIT quantum memory[2] to explore synchronizing the probabilistic photon source to a fixed clock rate. In addition to investigating typical parameters of quantum memories such as efficiency and maximum storage time, we will measure the attainable two-photon interference between a photon retrieved from the memory and one directly from the source.

[1] Mottola, R. et al., Optics Express **28**, 3159-3170 (2020)
[2] Buser, G. et al., PRX Quantum **3**, 020349 (2022)

Q 38.38 Wed 17:00 KG I Foyer

Towards a fully integrated SU(1,1) interferometer in a periodically poled Ti:LiNbO3 waveguide — •Jonas Babai-Hemati, Kai Hong Luo, Raimund Ricken, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098, Paderborn, Germany

There is an increasing interest in quantum interferometers in metrology as they can outperform their classical counterparts. The most prominent quantum interferometer is a SU(1,1) interferometer, which has a Mach-Zehnder configuration with the conventional passive beamsplitters replaced by nonlinear parametric sections. We designed and fabricated a fully integrated SU(1,1) interferometer on a single LiNbO3 chip. Optical waves are guided in Ti-indiffused waveguides. The parametric sections comprise of periodically poled sections for type II phase-matched paramentric down-conversion (PDC) in the telecom range. A series of electrooptic polarization converters (PC) and two electrooptic phase-shifters allows the manipulation of the phase- and/or polarization state in between the nonlinear sections. The exact phase-matching of PDC and PC can be adjusted via temperature tuning in three separate sections of the chip. We report on the design and the fabrication of the integrated chip as well as on the classical characterization of the individual components forming the circuit. Quantum measurements to study the interferometer performance in phase-sensing as well as the use of such a device for tailored quantum state preparations are presently in a planning stage.

Q 38.39 Wed 17:00 KG I Foyer

Optical Coherence Tomography with Undetected Photons Based on an Integrated PDC Source — •Franz Roeder, René Pollmann, Michael Stefszky, Victor Quiring, Raimund Ricken, Christof Eigner, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn

Interferometry allows us to perform phase measurements with high precision to gain information about a system of interest, e.g., in a classical Mach-Zehnder interferometer. Replacing passive beam splitters of a Mach-Zehnder interferometer with active elements, such as parametric down-conversion (PDC) sources yields a so-called SU(1,1) interferometer. By operating the SU(1,1) interferometer with two non-degenerate wavelengths, for instance in the mid-IR and visible, it becomes possible to retrieve the phase properties of an object interacting with the mid-IR light by measuring only the visible light.
Here, we utilize broadband non-degenerate type-II PDC in dispersion engineered periodically poled lithium niobate waveguides as active elements of such an interferometer, which brings the benefit of significantly reduced energy consumption for a given signal-to-noise ratio, and demonstrate optical coherence tomography (OCT) with undetected photons. Furthermore, we investigate the conditions for an optimized signal-to-noise ratio by compensating for losses in the interferometer in a differential pumping scheme.

Q 38.40 Wed 17:00 KG I Foyer

Criticality-Enhanced Precision in Phase Thermometry — •Mei Yu, H. Chau Nguyen, and Stefan Nimmrichter — University of Siegen, Siegen, Germany

Temperature estimation of interacting quantum many-body systems is both a challenging task and topic of interest in quantum metrology, given that critical behavior at phase transitions can boost the metrological sensitivity. Here we study non-invasive quantum thermometry of a finite, two-dimensional Ising spin lattice based on measuring the non-Markovian dephasing dynamics of a spin probe coupled to the lattice. We demonstrate a strong critical enhancement of the achievable precision in terms of the quantum Fisher information, which depends on the coupling range and the interrogation time. Our numerical simulations are compared to instructive analytic results for the critical scaling of the sensitivity in the Curie-Weiss model of a fully connected lattice and to the mean-field description in the thermodynamic limit, both of which fail to describe the critical spin fluctuations on the lattice the spin probe is sensitive to. Phase metrology could thus help to investigate the critical behaviour of finite many-body systems beyond the validity of mean-field models.

Q 38.41 Wed 17:00 KG I Foyer

Hyperpolarization of nuclear spins to mitigate diffusion broadening in liquid nanoscale NMR with NV centers — •Tobias Spohn[1], Nicolas Staudenmaier[1], Gerhard Wolff[1], Anjusha Vijayakumar-Sreeja[1], Genko Genov[1], Philipp Vetter[1], Raúl Gonzalez[1], Jochen Scharpf[2], Thomas Unden[2], Christoph Findler[1,3], Johannes Lang[3], Jens Fuhrmann[1], Philipp Neumann[2], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, Ulm University, Albert-Einstein-Allee 11, 89081 Ulm, Germany — [2]NVision Imaging Technologies GmbH, Wolfgang-Paul-Straße 2, 89081 Ulm, Germany — [3]Diatope GmbH, Buchenweg 23, 88444 Ummendorf, Germany

In liquid nanoscale NMR the amplitude and phase of the acquired signal changes due to molecular diffusion of the nuclear spins. This causes spectral broadening of the acquired signal and therefore impedes resolution of chemical shifts and J-coupling.

Here we present a technique to mitigate diffusion broadening in nanoscale NMR experiments by the use of hyperpolarization of nuclear spins. We explore two potential techniques: The para-hydrogen induced polarization (PHIP) technique and the use of the stabilized radical TEMPO to induce polarization on hydrogen nuclear spins. The NMR signal is detected by a high density, nanometer thick, shallow NV center ensemble layer and read out with a widefield microscope setup. The directional polarization of nuclear spins reduces spectral broadening as diffusion will no longer play a role anymore due to the average signal remaining the same.

Q 38.42 Wed 17:00 KG I Foyer

Excited state lifetime of NV-centers for magnetometry — •Ludwig Horsthemke[1], Jens Pogorzelski[1], Lutz Langguth[3], Robert Staacke[3], Markus Gregor[2], and Peter Glösekötter[1] — [1]Department of Electrical Engineering and Computer Science, FH Münster University of Applied Sciences, Stegerwaldstraße 39, Steinfurt, Germany — [2]Department of Engineering Physics, FH Münster University of Applied Sciences, Stegerwaldstraße 39, Steinfurt, Germany — [3]Quantum Technologies GmbH, Alte Messe 6, Leipzig, Germany

Magnetic field sensing using nitrogen vacancy centers has attracted a lot of attention in the recent past. Approaches using microwave (MW) excitation realize high sensitivities and spatial resolutions. They are however limited in their application due to the necessity of MW delivery. In contrast all-optical approaches simplify the sensor design in a step towards industry application. They can be implemented using fiber optics to construct a non-magnetic, high insulation resistance probe and can thereby be applied in harsh environments. These designs still encounter challenges such as movement in the optical fiber or laser intensity noise, compromising the fluorescence signal. In this study we utilize the fluorescence lifetime as a non-intensity quantity for magnetic field sensing. The lifetimes show a good correlation with the intensity by a reduction with a contrast of 8.3% upon application of magnetic fields. The integration of this approach holds promise for advancing magnetic field sensing capabilities, particularly in environments where conventional methods face limitations.

Q 38.43 Wed 17:00 KG I Foyer

Progress towards single photon EIT light storage at ZEFOZ conditions in Pr:YSO — •Marcel Hain, Tom Güntzel, and Thomas Halfmann — Nonlinear Optics & Quantum Optics (NLQ), Institute of Applied Physics, TU Darmstadt, Germany

Long storage time, large storage efficiency, and large signal-to-noise ratio (SNR) are crucial properties of optical quantum memories. We present single- and few-photon storage based on electromagnetically induced transparency (EIT) in praseodymium-doped yttrium orthosilicate (Pr:YSO). By employing zero first-order Zeeman shifts (ZEFOZ) and dynamical decoupling based on robust composite pulse sequences we reach storage times on the timescale of seconds. We apply a specifically designed spectral filter implemented in an additional Pr:YSO crystal to separate the weak signal pulse from the strong optical control field. Previously, we reached a SNR=1 for stored weak coherent pulses with 11 photons at a storage time beyond one second [1].

We present now recent progress towards single photon storage by EIT in Pr:YSO. We simultaneously prepare two ensembles to increase the optical depth, thereby enabling higher efficiency. Furthermore, we optimized the optical setup, among other measures using now an ECDL-based laser system (replacing the previously applied OPO system), which helps to improve the spectral filter discrimination by almost two orders of magnitude. This pushes the SNR towards the required regime for single photon storage.

[1] M. Hain, M. Stabel, and T. Halfmann. New J. Phys. **24**, 023012 (2022)

Q 38.44 Wed 17:00 KG I Foyer

Optimal valley control in 2D materials with subcycle laser pulses — •Arkajyoti Maity, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38,01187 Dresden

Information processing, using the valley degrees of freedom in inversion symmetric 2D materials is possible with the help of specifically designed ultrafast laser pulses. In our work, we theoretically show how linearly polarized terahertz subcycle laser pulses allow us to obtain a saturation of valley polarization (VP) in monolayer graphene . We further exploit the matching of the Thz drive time scales with dephasing rates in the material to get amplitude-controlled valley-polarized responses, namely residual photocurrents. We also present some results on pulse-shaping, both in spectral-phase and polarization domain, for efficient VP.

Q 38.45 Wed 17:00 KG I Foyer

Engeneering of tin vacancies in diamond by lattice charging — •Vladislav Bushmakin[1,2], Oliver von Berg[1], Santo Santonocito[1], Sreehari Jayaram[1,2], Rainer Stöhr[1], Andrej Denisenko[1,2], and Jörg Wrachtrup[1,2] — [1]Universität Stuttgart, 3. Physikalisches Institut, Allmandring, 13, 70569, Stuttgart, Germany — [2]Max-Plank-Institut für Festkörperforschung Heisenbergstraße 1, 70569 Stuttgart, Germany

Recent advances in integrating spin-bearing solid-state defects in optical cavities for efficient spin-photon entanglement are mostly associated with silicon vacancy in diamond. Meanwhile, the implantation of diamond with heavier group IV ions promises similar performance but at elevated temperatures above 1 K, which contrasts with the stringent requirement of approximately 100 mK for the coherent manipulation of the SiV electron spin. However, the generation of defects involving heavier atoms, such as tin, is accompanied by a high density of defects induced by ion implantation. Here we present a method of reduction of the implantation-induced density of defects by implanting through the Boron-doped charged lattice with a subsequent etching of the damaged layer. The given method is an extension of the conventional implantation technique and hence significantly less experimentally demanding than techniques relying on CVD overgrowth or HPHT annealing. Additionally, it provides better accuracy of implantation and allows for the efficient generation of tin vacancies with a narrow inhomogeneous zero-phonon line distribution.

Q 38.46 Wed 17:00 KG I Foyer

Spatial search via quantum walk on lattices with long-range hopping — •Moritz Linnebacher, Emma King, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany

Spatial search forms the basis of many noteworthy classical and quantum algorithms. In some settings, quantum spatial search achieves runtimes of $\mathcal{O}(\sqrt{N})$ compared to its classical counterpart with runtimes of $\mathcal{O}(N)$, where N is the size of the search space. In our work we implement spatial search via continuous-time quantum walk on lattices comprising N sites with long-range hopping. The hopping strength decays as $1/\ell^{\alpha}$ with inter-site distance ℓ and the exponent $\alpha \in [0, \infty)$. We focus on one- and two-dimensional lattices with $d = 1, 2$, where a rigorous numeric treatment shows that the search succeeds with high probability in $\mathcal{O}(\sqrt{N})$ runtime for $\alpha \leq d$, even in $d = 1$ spatial dimension. For lattices with nearest-neighbour interactions, corresponding to $\alpha \to \infty$, the quadratic speedup over classical spatial search is lost. This highlights the importance of considering long-range interactions for search in low-dimensional lattices.

Q 38.47 Wed 17:00 KG I Foyer

quantum optimal control for GHZ-class states — •yitian wang and christiane koch — Freie Universität Berlin, Berlin, Germany

We present an optimization functional that targets the entire class of GHZ states. Optimization has been carried out in trapped Rydberg atoms with varying number of qubits. Compared with state-state overlap based optimization functional, our functional can significantly reduce the resource required to produce a random GHZ state, thus facilitate protocols based on GHZ-class states.

Q 38.48 Wed 17:00 KG I Foyer

Correlations in two-photon-excited ion chains — •Zyad Shehata[1,3], Stefan Richter[1,2], Benjamin Zenz[4], Maurizio Verde[4], Ansgar Schaefer[4], Ferdinand Schmidt-Kaler[4], and Joachim von Zanthier[1,3] — [1]AG Quantum Optics and Quantum Information, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 1, 91058 Erlangen, Germany — [2]Photonscore GmbH, 39118 Magdeburg, Germany — [3]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Friedrich-Alexander-Universität Erlangen-Nürnberg, Paul-Gordan-Straße 6, 91052 Erlangen, Germany — [4]QUANTUM, Institut für Physik, Johannes Gutenberg Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

In this work, small crystals of trapped Ca-ions are studied using background-free coherent scattering and two-photon excitation via the D5/2 metastable state. The narrow quadrupole transitions allows for spin selective excitation and thus for far field imaging of the spin state of the crystals using G(1) function. The visibility of the interference pattern depends on the power and the detuning of the two lasers at 729 nm and 854 nm employed in the two-photon excitation as well as on the strength and orientation of the magnetic field that splits the ground state spin states. To calculate G(1), a full interaction Hamiltonian of the system including the two laser beams and all transitions involved is solved numerically for any number of ions, and experimental spatial frequencies of ion crystals are reconstructed for low exposure times (250 ms - up to 1 s) and detected by an ultra-fast picosecond-time-resolution camera.