Q 42: Poster III

Time: Wednesday 16:30–19:00 Location: Empore Lichthof

Q 42.1 Wed 16:30 Empore Lichthof

Fermionic coherent state path integral for ultrashort laser pulses and transformation to a field theory of coset matrices — •Bernhard Mieck — keine Institution

A coherent state path integral of anti-commuting fields is considered for a two-band, semiconductor-related solid which is driven by a ultrashort, classical laser field. We describe the generation of exciton quasi-particles from the driving laser field as anomalous pairings of the fundamental, fermionic fields. This gives rise to Hubbard-Stratonovich transformations from the quartic, fermionic interaction to various Gaussian terms of self-energy matrices; the latter self-energy matrices are solely coupled to bilinear terms of anomalous-doubled, anti-commuting fields which are subsequently removed by integration and which create the determinant with the one-particle operator and the prevailing self-energy. We accomplish path integrals of even-valued self-energy matrices with Euclidean integration measure where three cases of increasing complexity are classified (scalar self-energy variable, density-related self-energy matrix and also a self-energy including anomalous doubled terms). According to the driving, anomalous-doubled Hamiltonian part, we also specify the case of a SSB with hinge-fields which factorizes the total self-energy matrix by a coset decomposition into density-related, block diagonal self-energy matrices of a background functional and into coset matrices with off-diagonal block generators for the anomalous pairings of fermions. This allows to derive a classical field theory for the self-energy matrices of exciton quasi-particles by gradient expansions of the determinant.

Q 42.2 Wed 16:30 Empore Lichthof

Hybrid platform for quantum optic experiments — •Simon Haugg[1], Niklas Lettner[1], Lukas Antoniuk[1], Konstantin Fehler[1,2], Anna P. Ovvyan[3], Nico Gruhler[3], Valery A. Davydov[4], Viatcheslav N. Agafonov[5], Wolfram H. P. Pernice[3], 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]Moscow, Russia — [5]Universite F. Rabelais, 37200 Tours, France

In a hybrid approach, we are utilizing and manipulating the interaction of solid state quantum emitters in nano-hosts, such as color-centers in nano-diamonds, with classical Si_3N_4-based photonic crystal cavities, in order to yield an efficient spin-photon interface. We present our efforts to realize this goal, which paves the way to a realization of integrated on-chip hybrid quantum systems.

Q 42.3 Wed 16:30 Empore Lichthof

Orbital angular momentum modes generated in the parametric down-conversion process with a non-Gaussian pump — •Lucas Gehse, Dennis Scharwald, and Polina Sharapova — Universität Paderborn, Paderborn, Germany

Electric fields can carry two types of angular momentum. The first is the spin angular momentum, which arises from the polarization of the light, and the second is the orbital angular momentum (OAM) which arises from the light phase distribution. OAM modes have an unlimited basis, which makes them very promising for fast and efficient quantum information and communication protocols [1]. It has recently been shown that a radially symmetric parametric down-conversion (PDC) process is a good source of photons with perfectly anti-correlated orbital numbers in both low- and high-gain regimes [2]. In this work, we investigate an SU(1,1) interferometer consisting of two PDC sources, which are two nonlinear crystals pumped by a Laguerre−Gaussian pump with different orbital and radial numbers. We consider various crystal lengths, pump widths and distances between the crystals, in order to find configurations with high-order OAM modes populated. We have found configurations in which up to 120 OAM modes can be generated using a pump with different orbital numbers. Mode shapes and intensity profiles for various configurations of the SU(1,1) interferometer in the low- and high-gain regimes were investigated and discussed.

[1] Manuel Erhard *et al.*, Light Sci Appl **7**, 17146 (2018)
[2] Lina Beltran *et al.*, J. Opt. **19**, 044005 (2017)

Q 42.4 Wed 16:30 Empore Lichthof

An Experimental Setup to Study Amplification Without Inversion in Mercury — •Daniel Preissler and Thomas Walther — TU Darmstadt, Institute for Applied Physics, Laser and Quantum Optics, Schlossgartenstr. 7, D-64289 Darmstadt

For conventional laser sources, the required power to achieve the necessary population inversion scales with at least the fourth power of the laser frequency. This severaly limits the generation of lasers at short ultraviolet wavelengths and below. To overcome this problem, the coherent reabsorption can be suppressed by carefully employing atomic coherence effects. This is called lasing without inversion (LWI).

In a recent publication Rein et al. (Phys Rev. A **105** (2022) 023722) showed an experimental setup to study an LWI scheme in atomic mercury vapor, consisting out of two driving lasers at 435.8nm and 546.1nm, a repumper at 404.7nm and a probe system which doubles as a pump source at 253.7nm. This allowed for the further refinement of a theoretical model and its comparison with experimental data.

Based on this model, critical parameters towards achieving amplification withouth inversion (AWI) - a prerequisite for LWI - could be identified through simulations. This includes the power and spectral width of the pump system and the power of the strong driving field at 435.8nm.

In this contribution the results of those simulations as well as the experimental steps taken to improve on those parameters will be presented. Additionally, measurements of the observed three photon coherence effect will be discussed.

Q 42.5 Wed 16:30 Empore Lichthof

Rydberg Dark States on an Atom Chain Interacting with a Chiral Waveguide — •Tom von Scheven[1], Anne V. Jeschke[1], Igor Lesanovsky[1,2], and Beatriz Olmos[1,2] — [1]Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]School of Physics and Astronomy, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

We consider a laser-driven chain of atoms coupled to a chiral waveguide and investigate the possibility of creating so-called dark states, i.e. eigenstates of the atomic chain where the photons become trapped. Beyond their fundamental interest, atomic systems that host such dark states are nowadays widely investigated due to their potential applications in quantum information processing, e.g., as quantum memories. It has been previously found that, under the right combination of atomic and laser parameters, product states of entangled pairs (so-called dimer states) can be excited in a chain of two-level systems coupled to a chiral waveguide. Here, we analytically and numerically demonstrate the existence of a new class of entangled dark states by exploiting the strong interactions present in a chain of Rydberg atoms close to a waveguide. Compared to the dimer states, the conditions on the laser parameters necessary to excite a dark state (e.g. detuning pattern) are less restrictive. Moreover, these Rydberg dark states possess entanglement that is shared among all atoms are more robust against external perturbations, such as dissipation into unguided modes. Our results demonstrate the potential of using Rydberg atoms in quantum optical many-body systems in order to create dark states.

Q 42.6 Wed 16:30 Empore Lichthof

Modified dipole-dipole interactions in the presence of a nanophotonic waveguide — •Mathias Bo Mjøen Svendsen[1] and Beatriz Olmos[1,2] — [1]Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

When an emitter ensemble interacts with the electromagnetic field, dipole-dipole interactions are induced between the emitters. The magnitude and shape of these interactions are fully determined by the specific form of the electromagnetic field modes. If the emitters are placed in the vicinity of a nanophotonic waveguide, such as a cylindrical nanofiber, the complex functional form of these modes makes the analytical evaluation of the dipole-dipole interaction cumbersome and numerically costly. In this work, we provide a full detailed description of how to successfully calculate these interactions, outlining a method that can be easily extended to other environments and boundary conditions. Such exact evaluation is of importance as, due to the collective character of the interactions and dissipation in this kind of systems, any small modification of the interactions may lead to dramatic changes in experimental observables, particularly as the number of emitters increases. We illustrate this by calculating the transmission signal of the light guided by a cylindrical nanofiber in the presence of a nearby chain of emitters.

Q 42.7 Wed 16:30 Empore Lichthof

Organic dye molecules as possible candidates for spin-photon interfaces — •Max Masuhr and Daqing Wang — Institute of Physics, University Kassel, Heinrich-Plett-Straße 40, Kassel, Germany

Polycyclic hydrocarbon molecules are bright photon emitters, exhibiting high quantum efficiencies and narrow transition linewidths when embedded in matrices and cooled to liquid helium temperatures. The synthetic flexibility of molecules allows for tuning of their emission wavelengths and makes them promising candidates for linking with other quantum systems. Apart from the favorable photon emission properties between the singlet states, the long-lived triplet states in these molecules provide opportunities for quantum information storage. Here, we discuss lifetime measurements of the triplet states and investigate the feasibility of realizing a spin-photon interface based on the singlet-triplet transition in a single molecule.

Q 42.8 Wed 16:30 Empore Lichthof

Fiber-coupled plug-and-play heralded single photon source based on $Ti{:}LiNbO_3$ and polymer technology — •Christian Kiessler[1], Hauke Conradi[2], Moritz Kleinert[2], Viktor Quiring[1], Harald Herrmann[1], and Christine Silberhorn[1] — [1]Paderborn University, Integrated Quantum Optics, Institute of Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn — [2]Fraunhofer HHI Berlin, Einsteinufer 37, 10587 Berlin

A reliable, but cost-effective generation of single-photon states is key for practical quantum communication systems. Requirements like affordability, stability, miniaturized design and fiber compatibility are essential for these sources.
Here, we present the first chip-size fully integrated fiber-coupled Heralded Single Photon Source (HSPS) module based on a hybrid integration of Lithium-Niobate into a polymer board. A spontaneous parametric down conversion (SPDC) process with a pump wavelength of 532 nm leads to signal and idler of 810 nm and 1550 nm. The module has a size of $(2 \times 1)\,\mathrm{cm}^2$ and is fully fibercoupled with one pump input fiber and two output fibers for separated signal and idler. We measure a heralded second-order correlation function of $g_h^{(2)} = 0.05$ with a heralding efficiency of $\eta_h = 4.5\,\%$ at low pump powers.

Q 42.9 Wed 16:30 Empore Lichthof

Purcell-Enhanced Emission from Individual Color Center in Diamond to Photonic Crystal Cavities — •Lukas Antoniuk[1], Konstantin Fehler[1,2], Niklas Lettner[1,2], Anna P. Ovvyan[3,5], Richard Waltrich[1], Nico Gruhler[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

Classical photonic platforms combined with solid state quantum emitters, like the SiV^- center in diamond, enable for efficient quantum photonic devices. In a hybrid approach, we combine the SiV^- center in nanodiamonds with an efficient on-chip Photonic Crystal Cavity based on a Si_3N_4 photonic platform [1]. Utilizing an atomic force microscope, we developed a routine for placing and optimization of the emitter inside the mode of the cavity. For individual optical transitions of a single SiV^- center we achieved a Purcell enhancement of more than 4 as well as lifetimes as short as 450 ps [2].

[1] Fehler, Konstantin G., et al. ACS Nano 2019, 13, 6, 6891-6898.
[2] Fehler, Konstantin G., et al. ACS Photonics 2021, 8, 9, 2635-2641.

Q 42.10 Wed 16:30 Empore Lichthof

Optical Characterization of InGan/Gan-based nanowires — •Mohsen Esmaeilzadeh[1,2], Pablo Tieben[1,2], Soumyadip Chatterjee[3], Apurba Laha[3], and Andreas W. Schell[1,2] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [2]Institute for Solid State Physics, Leibniz University Hannover, 30167 Hannover — [3]Department of Electrical Engineering, Indian Institute of Technology Bombay,400076 Mumbai

Recent progress has been achieved in using GaN-based nanostructures as LEDs. GaN as a semiconductor exhibits great thermal and chemical stability and the potential for tuning the band gap by alloying with indium over visible wavelengths.

Indium composition in growing InGaN is very sensitive to temperature. The compositional non-uniformity in InGaN impacts the emission wavelength of the InGaN nanostructures. We are specifically investigating the optical properties of single InGaN/GaN-based nanowires grown on Si (111) substrate using RIBER MBE C21 system equipped with a Veeco plasma cell.

A high resolution SEM microscope was used to investigate the morphology and structure of single nanowires. We used confocal fluorescence microscopy technique to determine the corresponding optical emission properties for a broad range of excitation wavelengths in the visible spectrum. Moreover, we studied the possible damage threshold of the nanowires by exposing them to high laser power for an extended period of time and observing the stability of the emission. Simultaneously, we monitored the corresponding fluorescence spectrum.

Q 42.11 Wed 16:30 Empore Lichthof

A quantum Rabi model with two interacting qubits — •Thomas J. Hamlyn[1,2] and Weibin Li[1,2] — [1]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [2]Centre for the Mathematics and Theoretical Physics of Quantum Non-equilibrium Systems, University of Nottingham, Nottingham NG7 2RD, United Kingdom

We study a modified quantum Rabi model with a monochromatic bosonic mode and two qubits coupled via a spin-spin interaction. We focus on eigenstates of the model in two different regimes. Without qubit mixing, the Hilbert space can be divided into two symmetry sectors. It is found that the model can be reduced to the standard Rabi model, and therefore the eigenenergy can be obtained systematically through solving the so-called $\mathcal{G}$-function. With the qubit mixing, we study the superradiant phase transition with the mean field and direct diagonalization method, both giving consistent results. It is found that the symmetry of the ground state is broken. We explore the symmetry breaking by varying system parameters. Using a variety of methods, we show the dependence of the symmetry breaking on the qubit mixing

Q 42.12 Wed 16:30 Empore Lichthof

Optical properties of InGaN quantum dot embedded on GaN nanowire — •Hiren Dobariya[1], Pablo Tieben[1,2], Swagata Bhunia[3], Suddhasatta Mahapatra[3], Apurba Laha[3], and Andreas W. Schell[1,2] — [1]Institute for Solid State Physics, Gottfried Wilhelm Leibniz University, 30167 Hannover — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [3]Department of Electrical Engineering, Indian Institute of Technology Bombay, 400076 Mumbai

III-Nitride group-based materials, particularly Indium Gallium Nitride (InGaN) have emerged as one of the most critical materials for various applications, such as solid-state lighting, quantum technology, and scientific research. The unique nanostructure of GaN nanowires with quantum dots of InGaN embedded has been in focus for near-UV photonics research in general, as well as its room-temperature single photon generation. In this work, we present the detailed optical characterization of InGaN quantum dots embedded in GaN nanowires, grown by Plasma Assisted Molecular Beam Epitaxial (PAMBE) technique to realize sub-10 nm InGaN quantum dots exhibiting strong quantum confinement. We have carried out a detailed study on the optical characterizations of the InGaN quantum dots (QDs) in a home-built confocal microscope setup. The photoluminescence properties of the InGaN quantum dot at room temperature and cryogenic temperatures show strong emissions ranging from the green to red in the electromagnetic spectrum.

Q 42.13 Wed 16:30 Empore Lichthof

Machine-learning optimized entanglement in photonic topological insulators — •Saipavan Vengaladas[1,2], Armando Pérez-Leija[4], Kurt Busch[1,3], and Konrad Tschernig[4] — [1]Max-Born-Institut, 12489 Berlin, Germany — [2]Department of Physics, Freie Universität Berlin, 14195 Berlin, Germany — [3]Humboldt-Universität zu Berlin, AG Theoretische Optik & Photonik, 12489 Berlin, Germany — [4]CREOL/College of Optics & Photonics, University of Central Florida, Orlando, 32816 FL, USA

Photonic Floquet topological insulators feature so-called edge states, and wavepackets built from edge states are topologically protected. As a result, they naturally resist the scrambling effects of disorder and retain their shape during propagation. This useful property gives rise to the intriguing possibility of protecting two-photon entangled states. While the necessary conditions to protect two-photon entanglement in topological insulators (TIs) have been well established[1], it is yet unclear how to construct optimally entangled two-photon states. This is no trivial task since the degree of entanglement, and the amount of bulk scattering are naturally competing properties inside TIs. In this work, we take a more general approach by defining a black-box optimization problem, which is tackled using a machine-learning based Latent Action Monte Carlo Tree Search (LA-MCTS) meta-algorithm[2]. We present the optimized states that we obtain by exploring the space of all possible states and discuss their properties. [1] K.Tschernig et al., Nat. Commun.12, 1974 (2021). [2] arxiv.org/abs/2007.00708

Q 42.14 Wed 16:30 Empore Lichthof

On-chip single-photon subtraction by individual silicon vacancy centers in a laser-written diamond waveguide — Michael Koch[1,2], •Vibhav Bharadwaj[1,3], Michael Höese[1], Johannes Lang[1], John P. Hadden[4], Roberta Ramponi[3], Fedor Jelezko[1,2], Shane M. Eaton[3], and Alexander Kubanek[1,2] — [1]Institute for Quantum Optics, Ulm University, Ulm, Germany — [2]IQst, Ulm University, D-89081 Ulm, Germany — [3]Istituto di Fotonica e Nanotecnologie (IFN-CNR), Milan, Italy — [4]School of Physics and Astronomy, Cardiff University, Cardiff CF24 3AA, UK

Apart from its perfect to application properties of hardness, transparency and thermal conductivity, diamond has created an interest in the quantum technologies community due to naturally occurring imperfection in the form of color centers such as Nitrogen vacancy (NV) and Silicon Vacancy (SiV). They have emerged as candidates for quantum computing and field sensing applications. Recently, Laser writing has allowed 3-d formation of photonic and microfluidic devices in diamond [1] with the ability to integrate waveguide with Ion implanted single SiV centers. In this poster, we show single-emitter extinction measurements from SiV coupled to a waveguide demonstrating single-photon subtraction from a quasi-coherent field resulting in super-Poissonian light statistics[2]. Our architecture enables light field engineering in an integrated design on the single quantum level.

[1] Bharadwaj V et al. Journal of Physics: Photonics (2019): 022001
[2] M. K. Koch et al., ACS Photonics 9, 3366-3373 (2022)

Q 42.15 Wed 16:30 Empore Lichthof

Sum-frequency generation in diced ridge waveguides in periodically poled $LiNbO_3$ — •Noel Heinen, Christian Kiessler, Michelle Kirsch, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute of Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn

In order to make quantum technology commercially usable, it must be integrated into the existing optical C-band fiber network. However, there are devices based on nitrogen vacancies in diamonds with an operating wavelength of 639 nm, which therefore require a frequency converter interface. Here, we demonstrate a SFG process in titanium indiffused diced ridge waveguides in periodically poled $LiNbO_3$ for a conversion of 1550 nm and 1064 nm pump wavelengths to 630 nm. We performed simulations and mode field measurements to analyse the light guiding conditions of the waveguides and to find optimum fabrication parameters, since dicing of waveguides with a dicing saw is a new fabrication method in our group. We measure transmission losses below $0.8\,\frac{\mathrm{dB}}{\mathrm{cm}}$ and a normalized SFG conversion efficiency of $\eta_{\mathrm{norm}} = 7.4\,\frac{\%}{\mathrm{W\cdot cm^2}}$ at pump powers of a few milliwatts.

Q 42.16 Wed 16:30 Empore Lichthof

Open-system dynamics and fluctuation-dissipation relation in a photon Bose-Einstein condensate — •Aleksandr Sazhin[1], Göran Hellman[1], Fahri Emre Öztürk[1], Frank Vewinger[1], Johann Kroha[2], Vladimir Gladilin[3], Michiel Wouters[3], Martin Weitz[1], and Julian Schmitt[1] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, D-53115 Bonn — [2]Physikalisches Institut, Universität Bonn, Nussallee 12, D-53115 Bonn — [3]TQC, Universiteit Antwerpen, Universiteitsplein 1, B-2610 Antwerpen

The tuneable openness of optical quantum gases, as photon or polariton condensates in optical microcavities, enables the exploration of new system states and phases, which would not be accessible under closed system conditions. Here, we experimentally demonstrate a non-Hermitian phase transition in a photon Bose-Einstein condensate in an open dye-filled optical microcavity. The transition separates a phase of biexponential photon number correlations from both lasing and an intermediate, oscillatory regime, as characterised by the second-order correlation dynamics of the BEC [1]. By studying the magnitude of the condensate number fluctuations and relating them to a response function, we verify a fluctuation-dissipation relation for the BEC coupled to a molecular reservoir [2]. In more recent work, we have extended these studies to the time domain, establishing a connection between the fluctuation dynamics and the response of the condensate population to an external pulse-like perturbation of the molecular reservoir. [1] F. E. Öztürk et al., Science 372, 88 (2021) [2] F. E. Öztürk et al., arXiv:2203.13255 (2022)

Q 42.17 Wed 16:30 Empore Lichthof

Integrated Photonics for Quantum Computing and Communication — •Jonas Zatsch[1,3], Jeldrik Huster[1,3], Simon Abdani[1,3], Christian Schweikert[2], and Stefanie Barz[1,3] — [1]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute of Electrical and Optical Communications Engineering, University of Stuttgart, 70569 Stuttgart, Germany — [3]Center for Integrated Quantum Science and Technology (IQST)

Future quantum information research aims at the realisation of computationally powerful quantum computers and the secure implementation of quantum communication protocols. This requires an increasing number of components with small footprint, high phase stability and low-loss connectivity. A promising scalable technology is integrated quantum photonics, allowing for a compact and robust manipulation of photonic quantum bits. We present an integrated photonic chip, based on the silicon-on-insulator platform, enabling photonic quantum information processing. We demonstrate the generation of photonic quantum states on chip using integrated beam splitters and phase shifters. We show the conversion of quantum information from one degree of freedom – path – to another – polarisation – and vice versa. Combining this conversion with efficient fibre coupling allows one to connect several chips and thus the implementation of networked protocols for quantum communication and quantum computing.

Q 42.18 Wed 16:30 Empore Lichthof

Generalized Description of the Spatio-Temporal Biphoton State in Spontaneous Parametric Down-Conversion — •Baghdasar Baghdasaryan[1,2], Carlos Sevilla-Gutiérrez[3], Fabian Steinlechner[3,4], and Stephan Fritzsche[1,2,4] — [1]Theoretisch-Physikalisches Institut, Friedrich Schiller University Jena, 07743 Jena, Germany — [2]Helmholtz-Institut Jena, 07743 Jena, Germany — [3]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, 07745 Jena, Germany — [4]Abbe Center of Photonics, Friedrich Schiller University Jena, 07745 Jena, Germany

Spontaneous parametric down-conversion (SPDC) is a widely used source for photonic entanglement. Years of focused research have led to a solid understanding of the process, but a cohesive analytical description of the paraxial biphoton state has yet to be achieved. We present a simple-to-use closed expression for the biphoton state. The approach describes the full spectral and spatial properties of all interacting beams and applies to a wide range of experimental settings. The analytical treatment of the biphoton state decomposed into discrete Laguerre Gaussian (LG) modes also provides a deeper insight into the role of the Guoy phase in PDC. Especially, the coupling strength of spatial and spectral degrees of freedom (DOF) in PDC is fully controlled by the Gouy phase of pump, signal and idler beam. The control over the Gouy phase can be used to engineer entangled state separable in spatial and spectral DOF.

Q 42.19 Wed 16:30 Empore Lichthof

Generalized Ramsey Protocols — •Maja Scharnagl — Institute for theoretical physics, Leibniz University Hannover, Germany

We consider a variational class of generalized Ramsey protocols with two one-axis-twisting (OAT) operations, one before and one after the phase imprint, for which we optimize the direction of the signal imprint, the direction of the second OAT interaction and the measurement direction via a numerical routine for global optimization of constrained parameters. In doing so, we distinguish between protocols whose signal from spin projection measurements exhibits a symmetric or antisymmetric dependence on the phase to be measured. We find that the Quantum Fisher Information, which bounds the sensitivity achievable with a one-axis-twisted input state, can be saturated in our variational class of protocols for nearly all initial squeezing strengths. Therefore, the generalized Ramsey protocols considered here allow us to reduce quantum projection noise in comparison to the standard Ramsey protocol considerably.

Q 42.20 Wed 16:30 Empore Lichthof

Development of a stable, compact and cost-effective laser light source for resonant control of tin-vacancy color centres — •Franziska Marie Herrmann[1], Joseph Hugh Deakin Munns[1], Cem Güney Torun[1], and Tim Schröder[1,2] — [1]Integrated Quantum Photonics, Institut für Physik, Humboldt-Universität zu Berlin — [2]Diamond Nanophotonics, Ferdinand-Braun-Institut, Berlin

Tin-vacancy colour centres in diamond are promising candidates for nodes in quantum networks, due to their suitable optical and spin properties. However, with a zero phonon line wavelength of 619 nm, resonant excitation cannot be achieved easily by commercially available and affordable laser systems. At 1238 nm however, narrowband lasers are commercially available and the targeted 619 nm can be reached by frequency doubling. Here we introduce a stable and cost-effective lasersystem relying on second harmonic generation for resonant quantum control of tin vacancy centres, describe the stabilization measures taken and demonstrate the functionality of the system by driving all-optical rabi oscillations.

Q 42.21 Wed 16:30 Empore Lichthof

Properties of SiV centers in nanodiamonds for quantum networks — •Richard Waltrich[1], Marco Klotz[1], Niklas Lettner[1], Lukas Antoniuk[1], Viatcheslav Agafonov[2], and Alexander Kubanek[1] — [1]Institut für Quantenoptik, Universität Ulm — [2]Universite Francois Rabelais de Tours

The realization of a quantum network is of major interest. Combining the good optical and spin properties of group IV defects in diamond with established technologies in photonic-structure production puts such a platform into reach. We present measurements of characteristic properties of SiV centers in nanodiamond in comparison with bulk diamond, showing key features for the realization of a quantum network node.

Q 42.22 Wed 16:30 Empore Lichthof

Characterization of an ultra broadband integrated MIR photon pair source — •Abira Gnanavel, Franz Roeder, Olga Brecht, Christof Eigner, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Straße 100, 33098 Paderborn, Germany

Broadband photon-pairs from parametric down-conversion (PDC) are of interest for spectroscopy at low light levels and applications such as entangled two-photon absorption.

Here, we present the design and characterization of periodically poled lithium niobate waveguides to generate ultra-broadband, non-degenerate photon pairs via type II PDC in the near-infrared and mid-infrared regime. We especially engineer the dispersion of those waveguides regarding the quasi-phase matching condition.

We present a condition where the signal and idler photons are group velocity matched and furthermore group velocity dispersion matched that is, they propagate at the same velocity but incur opposite amounts of chirp. The photons are generated in a periodically poled titanium-indiffused lithium niobate waveguide at wavelengths of 800nm and 2800nm, well suited for detection and MIR probing. We expect a spectral bandwidth exceeding 27 THz for this process when pumping with a low-cost cw laser diode. A higher bandwidth in the frequency domain results in tighter correlations in the time domain and thus an increased photon simultaneity, which is desirable for ultrafast spectroscopy applications because it enables better measurement precision.

Q 42.23 Wed 16:30 Empore Lichthof

Quantum Fluctuation Forces between Trapped Nanospheres — •Clemens Jakubec[1], Kanupriya Sinha[2], Uros Delic[1], and Pablo Solano[3] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria — [2]School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ 85287-5706, USA — [3]Departamento de Física, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile

We present an analysis of the quantum fluctuation forces between two dielectric nanospheres trapped via optical tweezers. We develop a full quantum description of the radiative forces between the two nanospheres considering their mutual interaction mediated via the classical trapping field and the quantum fluctuations of the electromagnetic field. An analysis of the three separate contributions to the total potential – the Casimir-Polder potential, the classical trap potential and the optical binding potential – is presented. The total potential is subsequently studied as a function of various parameters, such as the tweezer field intensity and phase, demonstrating that, for appropriate sets of parameters, there exists a mutual bound state of the two nanospheres which can be $\sim$ 1000 K deep. Our results are pertinent to ongoing experiments with trapped nanospheres in the macroscopic quantum regime.

Q 42.24 Wed 16:30 Empore Lichthof

Characterization of an ultra-broadband integrated MIR photon pair source — •Abira Gnanavel, Franz Roeder, Olga Brecht, Christof Eigner, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Straße 100, 33098 Paderborn, Germany

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Q 42.25 Wed 16:30 Empore Lichthof

Photon correlations of trapped calcium ion crystal — •Zyad Shehata, Stefan Richter, Manuel Bojer, and Joachim von Zanthier — FAU Erlangen-Nürnberg, Quantum Optics and Quantum Information, Staudtstr. 1, 91058 Erlangen, Germany

Trapped ions are an important resource for quantum information science. Here, we study the collective light emission of trapped calcium ion crystals, in particular the photon auto- and cross-correlations. Simultaneous photon bunching and anti-bunching emerge from such systems [1]. In this work, we focus on the first-, second-, and third-order correlation functions of two- and three-ion crystals taking into account concrete experimental conditions, in particular the contrast-reducing Debye-Waller factor. Various illumination schemes of the ions are discussed in the context of the trap geometry, getting analytical and numerical solutions for the second- and third-order correlation functions, including predictions for their signal-to-noise ratio.

[1] S. Wolf, S. Richter, J. von Zanthier, F. Schmidt-Kaler, Light of Two Atoms in Free Space: Bunching or Antibunching?, Phys . Rev, Lett. 124, 063603 (2020)."

Q 42.26 Wed 16:30 Empore Lichthof

Cryogenic ensemble spectroscopy of Europium molecular complexes — •Weizhe Li, Evgenij Vasilenko, Jannis Hessenauer, Senthil Kumar Kuppusamy, Mario Ruben, and David Hunger — Karlsruhe Institut für Technologie, Karlruhe, Germany

Rare Earth Ions (REI) doped into solid state crystals have long optical coherence time and even longer spin coherence time. This makes REI a promising candidate for spin qubits which are optically addressable. For integration into photonic structures, nano-scale materials are of particular interest. In Europium-doped nanocrystals (Eu^{3+}:Y_2O_3), an optical coherence time of 3.7 μs and spin coherence time of 3 ms were obtained [1, 2, 3]. More recently, crystallized molecular complexes hosting REI have shown excellent optical coherence lifetimes of more than 10 μs and long spin population lifetimes [4], evidencing a quiet local environment.

This opens up a promising direction to explore further. In our research, we investigate different Eu^{3+}-based molecules including the complex used in [4]. We perform cryogenic ensemble spectroscopy and spectral hole burning and consistently observe long-lived spin states and narrow homogeneous optical linewidths.

[1] J. Bartholomew et al. Nano letters 17.2(2017), pp. 778-787.
[2] A. Perrot et al. Physical review letters 111.20 (2013), p. 203601.
[3] D. Serrano et al. Nature communications 9.1 (2018), pp. 1-7.
[4] D. Serrano et al. Nature 603.7900 (2022), pp. 241-246.

Q 42.27 Wed 16:30 Empore Lichthof

Cryogenic characterization of Electrical circuits — •Anupam Kumar, Niklas Lamberty, Thomas Hummel, and Tim J. Bartley — Institute for Photonic Quantum Systems, Paderborn University, Germany

Electrical components are typically optimized for operation near room temperature. Using these components for quantum photonics applications in the future will likely require operation at cryogenic temperatures since the measurement is often performed using superconducting detectors.

In this work, we characterize different electrical components made of various semiconductor platforms such as SiGe, GaAs, and InGaP. These commercial components are characterized at 4K and compared to each other for optimal performance. This allows the design of front-end electrical circuitry for SNSPDs, leading up to a single IC design.

Q 42.28 Wed 16:30 Empore Lichthof

Feed-forward for optical circuits with cryogenic electronics — •Niklas Lamberty, Thomas Hummel, Frederick Thiele, and Tim J. Bartley — Institute for Photonic Quantum Systems, Paderborn University, Germany

Many quantum optical experiments require high purity single-photon states. For this purpose, we developed a cryogenic electronic feed-forward circuit for selection of single-photon states from a PDC source. The photon number is measured using a photon number resolving superconducting detector array operated at 1 K and evaluated by an amplifier and a logic circuit based on SiGe Heterojunction Bipolar Transistor and CMOS technology. The circuit is operated in a cryostat at 2.5 K.

A total signal delay of (59 ± 7) ns and a heatload of more than 5 mW was measured. The circuit achieved reliable selection of single photon detection events, when tested with a coherent state, and creates signals usable for a modulator driver.

Q 42.29 Wed 16:30 Empore Lichthof

Quantumness and speedup limit of a qubit under transition-frequency modulation — •Amin Rajabalinia[1], Mahshid Khazaei Shadfar[2,3], Farzam Nosrati[2,3], Ali Mortezapour[1], Roberto Morandotti[3], and Rosario Lo Franco[2] — [1]Department of Physics, University of Guilan, P. O. Box 41335-1914, Rasht, Iran — [2]Dipartimento di Ingegneria, Universit'a di Palermo, Viale delle Scienze, 90128 Palermo, Italy — [3]INRS-EMT, 1650 Boulevard Lionel-Boulet, Varennes, Quebec J3X 1S2, Canada

we investigate the ability of a frequency-modulated qubit embedded in a leaky cavity to maintain quantumness. To detect quantum coherence as the main distinguishing feature of the quantum world from the classical one, tomographic methods are used to reconstruct the density matrix of quantum systems. Although the implementation of such a strategy poses a technical challenge in terms of experimental measurement settings, Leggett-Garg inequality and quantum witness have been introduced as quantum indicators to quantify the nonclassicality of a system in order to overcome the complexity of detection in the experiment. The quantum witness is based on the classical no-signaling-in-time assumption, which states that a previous experiment has no effect on the statistical outcome of the subsequent experiment. We compare a standard quantum witness (SQW) and a recently introduced optimized quantum witness (OQW) as experimentally friendly figures of merit [Phys. Rev. A 101, 012331 (2020)]. The OQW successfully identifies quantum coherence protection via frequency modulation, whereas the SQW fails.

Q 42.30 Wed 16:30 Empore Lichthof

Towards the observation of collective radiance phenomena in a one-dimensional array of waveguide-coupled atoms with sub-$\lambda/2$ spacing — •Lucas Pache, Martin Cordier, Max Schemmer, Philipp Schneeweiss, Jürgen Volz, and Arno Rauschenbeutel — Department of Physics, Humboldt-Universität zu Berlin, Germany

Recently, it has been shown theoretically that the infidelity of photon storage and retrieval in quantum memories scales exponentially better with the number of emitters if one harnesses the collective response of closely spaced atomic arrays [1,2]. This improved scaling relies on the effect of selective radiance, i.e., destructive interference of scattering into undesired modes. This occurs when the mean distance in a periodic array of emitters is smaller than half of the atomic resonant wavelength ($d < \lambda/2$). In order to realize this situation, we trap and optically interface laser-cooled cesium atoms using a two-color nanofiber-based dipole trap which is composed of a blue-detuned partial standing wave and a red-detuned running wave light field. The resulting trapping potential consists of one-dimensional trapping sites which are spaced by $d \simeq 0.37\lambda$. We characterize this trapping configuration by measuring the trap frequencies as well as the lifetime and the total number of the trapped atoms.

[1] A. Asenjo-Garcia et al. PRX 7, 031024 (2017)
[2] M. Manzoni et al. NJP 20, 083048 (201

Q 42.31 Wed 16:30 Empore Lichthof

Multimode squeezed states in coherent optical time-frequency networks — •Patrick Folge, Matteo Santandrea, Michael Stefszky, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Linear optical quantum networks are powerful tools in modern quantum applications and have gained a lot of attention due to their role in proving quantum computational advantages. Here, we present a resource efficient method for the implementation of linear optical quantum networks in a high-dimensional time-frequency encoding. We consider a multimode squeezing source based on type-0 parametric down-conversion (PDC) in the high gain regime as the quantum input of the system. To implement a linear optical network in the frequency bin basis we consider the use of a so-called quantum pulse gate (QPG), which allows for time-frequency mode selective frequency conversion. Here, the QPG is applied to coherently filter out input bins from the multimode squeezed state and superimpose them on the output ports of the QPG. This allows for the implementation of fully programmable linear quantum networks on the frequency bin basis. Here, we present our theoretical modeling of this system by applying it to the simple case of a frequency beam splitter. In this modelling we find that wider coherent filtering of the selected bins improves the performance of the network.

Q 42.32 Wed 16:30 Empore Lichthof

A few-MHz linewidth tunable optical filter based on a fibre-ring-resonator — •Gabriele Maron, Xinxin Hu, Luke Masters, Jürgen Volz, and Arno Rauschenbeutel — Department of Physics, Humboldt Universität zu Berlin, 10099 Berlin, Germany

We present a design for an ultra-narrowband, tunable optical filter, which is based on a fibre ring resonator. It consists of a fibre coupler with a variable splitting ratio, which allows us to set the filter linewidth and on-resonance transmission. At the same time, we set and actively stabilize the central frequency of the filter by means of actuators that change the optical round trip length of the fibre-ring. Operated in a notch-filter configuration, we recently used this device to isolate and investigate the incoherent emission from a single optically trapped atom, which was excited with near-resonant laser light [1]. The addition of a second variable fibre coupler into the fibre-ring extends the device's utility for filtering in an add-drop configuration. In this case, our characterisation reveals a resonator linewidth significantly narrower than the D_2 transition of ^{85}Rb, while maintaining a high transmission into the drop port. The tunability of the filter properties presents our device as a versatile platform for selective frequency filtering with a subnatural atomic linewidth resolution.

[1] L. Masters et al, arXiv:2209.02547 (2022)

Q 42.33 Wed 16:30 Empore Lichthof

Implementation of a sub 10 ps RMS jitter TDC for Hanbury Brown Twiss measurements in Astronomy — •Verena Leopold[1], Yury Prokazov[2], Evgeny Trubin[2], Stefan Richter[1], and Joachim von Zanthier[1] — [1]FAU, Erlangen, Germany — [2]Photonscore, Magdeburg, Germany

For Hanbury Brown Twiss measurements in Astronomy, it is crucial to detect photon arrival times very precisely from multiple detectors. Usually a TDC (Time-to-Digital- Converter) is used for recording this time stream. However, for these low contrast, long-running measurements, available TDCs show disadvantages. The main challenges are low quality analog inputs and non-linearities on short ps-timescales. We succesfully implemented a TDL (Tapped-Delay-Line) TDC inside an FPGA displaying a RMS jitter of (3.24±0.03) ps with non-linearities on the order of 0.32%. As a next step the TDC will be tested in the lab before measuring a real star in Calern.

Q 42.34 Wed 16:30 Empore Lichthof

Manipulation of fluorescence emission as a tool for quantum optics experiments — •Yannick Weiser, Lorenz Panzl, Giovanni Cerchiari, and Rainer Blatt — University of Innsbruck, Technickerstraße 25, 6020 Innsbruck, Austria

We control the spontaneous emission of a trapped Ba^+ ion by back reflecting the fluorescence light of the ion onto itself via a mirror. Due to this retro reflection, the emitted photon interferes with itself, which enhances, or suppresses the emission rate, depending on the ion-mirror distance. We are working in two regimes. A static one, where the distance between the ion and the mirror is fixed and a dynamic one, where the optical path length is modulated. In both cases, applications in the field of quantum optics and quantum optomechanics are investigated.

In the static regime, we will alter the decay rate of the ion with a spherical mirror. This can suppress the fluorescence rate to 6% of its natural value. Using the spherical mirror, not only position measurements down to the quantum level are possible, but also the variance of the motional state becomes accessible. Since this scheme relies on the interaction of the fluorescence light with the emitter, no narrow internal transition is needed.

In the dynamic regime, the ion-mirror optical path will be modulated with a phase modulator. By driving the modulation with the motional frequency of the ion we can cool, or excite the ion's motion.

Q 42.35 Wed 16:30 Empore Lichthof

Second-order correlations of scattering electrons — •Florian Fleischmann[1], Mona Bukenberger[2], Raul Corrêa[3], Anton Classen[4], Simon Mährlein[1], Marc-Oliver Pleinert[1], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Department of Environmental Systems Science, ETH Zürich, 8092 Zürich, Switzerland — [3]Departamento de Física, Federal University of Minas Gerais, 31270-901 Belo Horizonte, Brazil — [4]Department of Soil and Crop Sciences, Texas A&M University, TX 77843 College Station, USA

We investigate the spatial second-order correlation function of two scattering electrons in the far field. First, we consider semi-classically the effects of the Pauli exclusion principle and Coulomb repulsion on the expected correlation pattern. This is followed by a full quantum-mechanical treatment of the problem. For this, we separate the system into center-of-mass and relative coordinates in analogy to the hydrogen atom ansatz. While the center-of-mass system is described as a free particle, we solve the Coulomb scattering problem in the relative system. We expand the respective initial state of the electrons in the eigenstates of the scattering problem. After incorporating the time evolution, the function is evaluated in the far field. We show the formal solution to the problem and discuss the current state of the numerical investigations.

Q 42.36 Wed 16:30 Empore Lichthof

Optimised single photon sources based on monolithic cavity-enhanced spontaneous parametric downconversion — •Helen Chrzanowski[1], Xavi Barcons Planas[1], and Janik Wolters[1,2] — [1]German Aerospace Center (DLR), Berlin, Germany — [2]Technische Universität Berlin, Berlin, Germany

Despite its limitations, spontaneous parametric downconversion (SPDC) remains the favoured platform for single photon generation in quantum information (QI) science. Exploiting developments in non-linear optics, recent years have ushered in increasingly sophisticated approaches to source engineering, including group velocity matching, waveguide geometries and bespoke poling techniques. Another approach of growing interest embeds the non-linear crystal within an optical cavity. Cavity-enhanced SPDC enjoys several advantages: firstly, it shifts accessible photon bandwidths from THz to GHz, enabling efficient interfacing with matter-based qubits. Such narrow spectral bandwidths also protect photon pairs from the deleterious effects of material dispersion. Secondly, the confinement of a cavity yields precise selectivity of spectral and spatial modes while also enhancing brightness - allowing high efficiencies and purities. Here, we theoretically investigate photon pair sources in resonant monolithic cavities utalising PPLN and PPKTP. We find design parameters that simultaneously optimise purity and (heralding) efficiency, while also allowing for spectral tunablity and requiring limited filtering. The development of highly pure and efficient narrowband photon pairs is a crucial tool to realise next generation of QI demonstrations.