Q 28: Poster – Quantum Optics

QED and Cavity QED; Quantum Control; General Quantum Optics

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

Q 28.1 Tue 17:00 Philo 2. OG

Few-Photon SUPER: Quantum emitter inversion via two off-resonant photon modes — •Quentin Richter[1], Jan Kaspari[1], Thomas Bracht[1], Leonid Yatsenko[2], Martin Axt[3], Arno Rauschenbeutel[4], Moritz Cygorek[1], and Doris Reiter[1] — [1]Condensed Matter Theory, TU Dortmund — [2]Institute of Physics, National Academy of Science of Ukraine — [3]Lehrstuhl für Theoretische Physik III, Universität Bayreuth — [4]Department of Physics, Humboldt-Universität zu Berlin

The interaction of a two-level system with a light field is one of the most important models in quantum optics.
In this contribution, we investigate a Jaynes-Cummings model with two non-degenerate, off-resonant, photon modes coupled to a two-level emitter. We find parameters, for which we can identify a multi-photon scattering leading to full inversion of the emitter while transferring off-resonant photons from one mode to the other.
The results can be understood as a quantized analogue of the off-resonant quantum control scheme known as Swing-UP of quantum EmitteR (SUPER). Unlike the SUPER scheme, which requires two off-resonant pulses to be present at all times, our model only needs one mode initially occupied and the other mode available to achieve full emitter inversion.
Our results enable novel schemes of photon control for quantum photonics.

Q 28.2 Tue 17:00 Philo 2. OG

Fractal geometry dictates the scaling of atom-photon bound states — •Florian Bönsel[1,2], Federico Roccati[1,3], and Flore Kunst[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Dipartimento di Fisica e Chimica - Emilio Segre, Universita degli Studi di Palermo, I-90123 Palermo, Italy

We investigate the formation of atom-photon bound states in self-similar photonic lattices and derive a universal scaling law linking the localization length to the atom-bath detuning. By utilizing the heat-kernel representation of the Green's function, we circumvent the momentum-based approaches standard in waveguide QED. A key finding is that the scaling exponent is governed solely by the walk dimension, which characterizes classical anomalous diffusion, rather than the fractal or spectral dimension. This establishes a novel link between static quantum localization and dynamical transport. Numerical simulations on several fractals, such as Sierpinski and Vicsek graphs, confirm the derived results.

Q 28.3 Tue 17:00 Philo 2. OG

Cavity QED experiments and lasing with cold trapped Yb atoms — •Ke Li[1], Saran Shaju[1], Dmitriy Sholokhov[1], Simon B. Jäger[2], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken, Germany — [2]Universität Bonn, Physikalisches Institut, 53115 Bonn, Germany

Cavity quantum electrodynamics with cold atoms enables highly controlled interaction between atoms and photons, offering advanced applications in quantum technologies and fundamental science. In our research, 10^4 to 10^6 ^{174}Yb atoms are magneto-optically trapped, using the $^1S_0-^1P_1$ transition at 399 nm, inside a high-finesse cavity that couples to the $^1S_0-^3P_1$ intercombination transition at 556 nm. We have observed continuous lasing action in both single- and multi-mode emission [1]. When the atoms are magneto-optically trapped on the 556-nm transition, the collective strong coupling leads to complex atom-field dynamics and scattering phenomena, including vacuum Rabi splitting accompanied by additional fluorescence at atomic resonance [2]. Future research will be extended to interactions on the $^1S_0-^3P_0$ clock transition at 578 nm.

[1] H. Gothe et al., Phys. Rev. A 99, 013415 (2019).
[2] S. Shaju et al., Phys. Rev. A 112, 013705 (2025).

Q 28.4 Tue 17:00 Philo 2. OG

Controlling Quantum Gases in an Optical Cavity Through Continuous Measurement and Markovian Feedback — •Marcus Hofmann[1], Tobias Donner[2], Francesco Petiziol[1], and André Eckardt[1] — [1]Institut für Physik und Astronomie, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Institute for Quantum Electronics, ETH Zürich, 8093 Zürich, Switzerland

Ultracold quantum gases in optical cavities represent a powerful platform for exploring driven-dissipative quantum many-body physics. They have enabled the experimental observation of collective nonequilibrium effects induced by atom-light interactions, ranging from atomic self-organization and superradiance to nonequilibrium topological phases. In this project, we theoretically investigate a quantum-gas cavity QED setup endowed with the possibility to perform active feedback conditioned on the output of continuous measurements of the cavity field, as it has been realized in experiments at ETH Zürich. After developing a theoretical and numerical framework to describe the system, based on Wiseman-Milburn's formalism of Markovian quantum feedback, we explore the opportunities to control the state of the atoms and influence their ordering patterns by means of realistic measurement and feedback schemes.

Q 28.5 Tue 17:00 Philo 2. OG

Depletion dynamics of a Bose-Einstein condensate in a dissipative optical cavity — •Gage Harmon[1], Giovanna Morigi[1], Tom Schmit[1], and Simon Jäger[2] — [1]Saarland University — [2]University of Bonn

We study the depletion dynamics of a driven homogeneous Bose*Einstein condensate (BEC) strongly interacting with an optical cavity. Working in the bad-cavity regime, we eliminate the photonic degrees of freedom to obtain an effective atom-only master equation. Applying Bogoliubov theory, we derive the dynamics of the covariance matrix of the cavity-coupled atomic fluctuations. The resulting Lyapunov equation captures fluctuations arising from coherent and dissipative cavity-mediated interactions, as well as diffusive cavity shot noise. This system exhibits a self-organization (SO) phase transition and we analyze the depletion of the BEC in the normal (below threshold) and self-organized (above threshold) phases. Below threshold, we define an effective temperature for the cavity-coupled Bogoliubov mode and, in the weak-driving limit, derive an analytic expression consistent with previous results. Above threshold, the dominant depletion mechanism crosses over: near the SO transition, diffusion dominates, whereas deeper in the SO phase cavity-mediated atomic fluctuations prevail. We compare these cavity-induced depletion rates with those from short-range contact interactions obtained from Bogoliubov theory. With this we identify regimes in which cavity dissipation can, in principle, stabilize the condensate.

Q 28.6 Tue 17:00 Philo 2. OG

Generation of squeezed state superpositions of light with an atom-cavity system — •Maurizio Trigilia, Raphael Benz, Sebastian Alejandro Morales Ramirez, Micha Kappel, Daniel Reigel, Luis Weiss, Vincet Beguin, Leon Layer, Violet Ruf, and Stephan Welte for the QNN-Collaboration — 5. Physikalisches Institut, Center for Integrated Quantum Science and Technology and CZS Center QPhoton, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany.

We present an experimental protocol that employs an atom-cavity system to generate superpositions of squeezed states of light [1]. To achieve this, a displaced squeezed light state is reflected from an atom-cavity system with the atom prepared in a superposition of a coupling and a non-coupling state. A subsequent measurement of the atom projects the light onto a squeezed Schrödinger-cat state of even or odd parity, depending on the measurement outcome. The scheme can be extended to generate optical Gottesman-Kitaev-Preskill states [1]. In a practical scenario, optical losses lead to a deterioration of the generated light states. We present a theoretical framework that incorporates these losses and apply it to a parameter regime that describes our novel atom-cavity system that is currently in the buildup phase. Our simulations allow us to estimate experimentally achievable state fidelities. We furthermore show simulations of the transport of atoms with an optical dipole trap from a 3D magneto-optical trap into our optical cavity. [1] J. Hastrup, U. Andersen, Phys. Rev. Lett. 128 (17), 170503 (2022).

Q 28.7 Tue 17:00 Philo 2. OG

Development of an experimental setup for quantum network experiments based on neutral atoms in an optical cavity — Raphael Benz, •Sebastián Alejandro Morales Ramírez, Micha Kappel, Daniel Reigel, Maurizio Trigilia, Luis Weiss, Vincent Beguin, Leon Layer, Violet Ruf, and Stephan Welte for the QNN-Collaboration — 5. Physikalisches Institut, Center for Integrated Quantum Science and Technology and CZS Center QPhoton, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany.

The practical implementation of a quantum coherent network remains a pursued challenge across various hardware platforms. Cold neutral atoms trapped in a high-finesse optical cavity have proven to be a promising platform due to the efficient light-matter coupling and precise controllability of the system. Using optical tweezers to address individual atoms opens the possibility of extending this platform to versatile multi-qubit quantum network nodes. We present the progress and current status of our experimental setup with an emphasis on the planned vacuum system and the cavity design. We designed a 650-um-long cavity with a finesse of 40,000; it consists of two macroscopic super-polished mirrors, enabling single-atom cooperativities of C=5.2. To suppress mechanical vibrations, we developed a three-stage vibration isolation system. We discuss the mounting of this new setup. With our system, a wide range of experiments becomes feasible, including photon-mediated quantum information processing between intra-cavity atoms, the generation of highly entangled photonic cluster states, and the creation of optical GKP states.

Q 28.8 Tue 17:00 Philo 2. OG

Qubit entanglement via a single-mode Gaussian lateral defect Fabry-Perot cavity — •Ruolin Guan[1], Pengji Li[2], Xian Zheng[2], Vineesha Srivastava[3], Chenxi Ma[2], Eddy P. Rugeramigabo[2], Michael Zopf[2,4], Klemens Hammerer[1,3], and Fei Ding[2,4] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Institute of Solid State Physics, Leibniz University Hannover, Germany — [3]Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Innsbruck, Austria — [4]Laboratory of Nano and Quantum Engineering, Leibniz University Hannover, Germany

We propose a chip-compatible DBR Fabry-Perot cavity with a lateral Gaussian defect that allows two InAs/GaAs quantum dots to couple to a single optical mode. Using full-wave FDTD simulations and a single-mode Green-function mapping, we derive the collective decay rate and the exchange coupling. These parameters can be tuned continuously via the relative phase, enabling transitions between superradiant, subradiant, and dispersive regimes within the same device. We further show that the second-order correlation function serves as an experimentally accessible entanglement witness, and demonstrate two prototypes: a superradiant single-photon source and a dissipatively protected quantum phase gate.

Q 28.9 Tue 17:00 Philo 2. OG

Design and simulation of circular Bragg grating cavities for enhanced emission and spin readout of silicon C centers — •Junchun Yang[1], Alessandro Puddu[1,2], Shuyu Wen[2], Sourav Dev[1], Shengqiang Zhou[2], Yonder Berencén[2], and Kambiz Jamshidi[1] — [1]TU Dresden, Dresden, German — [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Color centers are optically addressable atomic-scale defects in solid-state hosts that enable the coherent control of individual spins and the generation of quantum light. Among them, silicon-based color centers are particularly attractive owing to technological maturity, CMOS compatibility, and scalability. Recently, we demonstrated optically detected magnetic resonance (ODMR) of an ensemble of silicon C centers, revealing the energy-level structure and spin-selective optical transitions. Here, we aim to enhance both the emission rate and photon collection efficiency of the silicon C center through integration with a photonic cavity. A circular Bragg gratings (CBG) cavity provides a moderate Purcell factor while its rotational symmetry ensures efficient upward coupling for any in-plane dipole. Additionally, the broad cavity linewidth enables spectral overlap without post-fabrication tuning. In this work, we use finite-difference time-domain (FDTD) simulations in Lumerical to design a CBG cavity, achieving a theoretical Purcell enhancement of 11 and a collection efficiency of 40%.

Q 28.10 Tue 17:00 Philo 2. OG

Single-pulse SUPER — •Jonas Köglmayr[1], Paul Constantin Alexander Hagen[1], Doris Reiter[2], Moritz Cygorek[2], and Vollrath Martin Axt[1] — [1]Lehrstuhl für Theoretische Physik III, Universität Bayreuth, Germany — [2]Condensed Matter Theory, TU Dortmund, Germany

Optical control is essential for efficient single-photon generation in quantum technology applications. The Swing-UP of Quantum EmitteR population (SUPER) mechanism is an approach to coherently control a quantum emitter by using two detuned laser pulses. Recently, SUPER has been extended to a fully quantized picture where two detuned cavity modes replace the pulses. Here we consider a different variation of SUPER where a single detuned laser pulse drives a quantum emitter coupled to an off-resonant cavity. As only one laser is needed compared to the original proposal, we term this the Single-pulse SUPER scheme. Using a dressed-state picture we explain the numerically observed dynamics and resonance conditions. We demonstrate that a high population inversion is theoretically feasible even when realistic cavity losses and emitter relaxation processes are taken into account. In addition to preparing the emitter in the upper state a photon is stored in the cavity. Thus, after completing the preparation a single photon is emitted by de-exciting the emitter and a second spectrally distinct single photon can be released from the cavity. These insights suggest that this system could be a source of two distinct single photons paving the way for a broad range of photonic applications.

Q 28.11 Tue 17:00 Philo 2. OG

Interacting bosonic system — •Margherita Valenza[1,2], Flore K. Kunst[1,2], and Anton Montag[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander Universitat Erlangen-Nurnberg, Staudtstraße 7, 91058 Erlangen, Germany

The collective behaviour of many-body systems is one of the main interests of contemporary quantum physics, particularly within the frameworks of nonlinear optics and Bose-Einstein condensate. In our case, we explore a tight binding model of coupled cavities array where there is the competition between coherent and incoherent effects. From the perspective of open quantum system, this interplay can create robust quantum resources and new phases of matter can arise as a consequence of the nontrivial behaviour of the steady state. As a consequence, the time-dependent simulations of the coherence matrix reveal a nontrivial effect in the regime of parameter that could be unstable in the absence of dissipation, but becomes stable due to cavity decay. These results highlight a nontrivial interplay between hopping, nonlinear drive and dissipation in engineered photonic systems.

Q 28.12 Tue 17:00 Philo 2. OG

Re-entrant phase transition in many-body Cavity QED — •Tom Schmit[1], Laura Batini[2], Justyna Stefaniak[3], David Baur[3], Gabriele Natale[3], Fabian Bennati Weis[3], Nicolò Defenu[2], Tobias Donner[3], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Institut für Theoretische Physik, Eidgenössische Technische Hochschule Zürich, Wolfgang-Pauli-Straße 27, 8093 Zürich, Switzerland — [3]Institute for Quantum Electronics, Eidgenössische Technische Hochschule Zürich, Otto-Stern-Weg 1, 8093 Zürich, Switzerland

A driven quantum gas of atoms in an optical cavity offers a powerful platform for exploring the equilibrium properties of long-range interacting systems. The interplay between the external drive, quantum fluctuations, and the cavity-mediated long-range interaction can lead to the formation of stable self-organized structures. When the system is transversaly driven with a laser that is blue-detuned from the atomic transition, an intriguing behaviour is observed: as the drive strength increases, the system first undergoes a transition from the normal phase to a self-organized phase at a critical threshold, but then, at a higher threshold, exhibits a *re-entrant phase transition* back to the normal phase, as experimentally demonstrated[1]. In this work, we develop a Ginzburg-Landau model for the transition between the normal and self-organized phases, based on a mean-field ansatz. This framework allows us to identify the mechanisms that stabilize and destabilize the self-organized state, giving the re-entrant behaviour.

Q 28.13 Tue 17:00 Philo 2. OG

Heralded generation of atom-photon entanglement — •Pau Farrera[1,2], Gianvito Chiarella[1], Tobias Frank[1], Leart Zuka[1], and Gerhard Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, D-80799 München

Reducing inefficiency and infidelity errors in quantum communication operations is essential in order to implement advanced quantum communication schemes. While heralding photonic quantum states at their reception allows to track and reduce propagation and measurement errors, heralding the generation of such states allows to immediately and faithfully react upon source errors. Here we implement a new method to track and mitigate errors in the generation of atom-photon entanglement. The method is based on the cascaded two-photon emission of a single atom into two crossed fiber cavities. The polarization state of one photon is entangled with the spin degree of freedom of the atom, and the second photon heralds the successful entanglement generation. We show that heralding improves the atom-photon entanglement in-fiber efficiency and fidelity to 68(3)% and 87(2)%, respectively. We highlight the potential of our source for noise-limited long-distance quantum communication by extending the range for constant fidelity or, alternatively, increasing the fidelity for a given distance.

Q 28.14 Tue 17:00 Philo 2. OG

Self-consistent matter description of the Dicke-Ising chain — •Jonas Leibig, Max Hörmann, Anja Langheld, Andreas Schellenberger, and Kai Phillip Schmidt — Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

The Dicke-Ising model admits an exact thermodynamic limit mapping to a self-consistent effective matter Hamiltonian [2], where the photon mode enters only as an effective transverse field. In our recent work [1], we apply this mapping and solve the resulting self-consistent spin model using a high-precision NLCE+DMRG approach. This allows us to obtain the thermodynamic-limit phase diagram in one dimension, resolving the ferromagnetic multicritical point with an accuracy of 10^{-4}, and confirm the narrow antiferromagnetic superradiant phase.

References

[1] J. Leibig, M. Hörmann, A. Langheld, A. Schellenberger, and K. P. Schmidt, “Quantitative NLCE+DMRG approach for 1D Dicke-Ising models via self-consistent matter Hamiltonians’, *to be published* (2025).
[2] J. Román-Roche, Á. Gómez-León, F. Luis, and D. Zueco, “Linear response theory for cavity QED materials at arbitrary light–matter coupling strengths”, *Physical Review B* **111**, 035156 (2025).

Q 28.15 Tue 17:00 Philo 2. OG

An atomic tweezer array with strong cavity coupling — •Johannes Schabbauer[1,2], Stephan Roschinski[1,2], Franz von Silva-Tarouca[1,2], Damien Bloch[1,2], and Julian Leonard[1,2] — [1]Atominstitut, Vienna Center for Quantum Science and Technology (VCQ), TU Wien, Austria — [2]Institute of Science and Technology Austria (ISTA), Klosterneuburg, Austria

The efficient generation of many-body entangled states is a key challenge for enabling useful quantum technologies. In some experiments with ultra-cold neutral atoms, entanglement can be created via local processes, like Rydberg or dipolar interactions. However, if one wants to efficiently create many-body states with non-local entanglement, like GHZ-states, having a process that is inherently non-local is desired. We realize this via photon-mediated interactions, by strongly coupling atoms to an optical cavity. In our experiment we achieve a very efficient light-matter interface by using a high-finesse fiber cavity with a Purcell factor of 160. For strong confinement within the cavity mode, the atoms are trapped in an array of optical tweezers. The tweezers enable site-resolved fluorescence imaging, and we use the cavity transmission for non-destructive readout of the atomic state. To control the atom-cavity coupling, we move the position of each tweezer with respect to the cavity mode. In addition, we will tune the cavity-mediated interactions of each atom individually via local lightshifts. This toolbox enables use to prepare and study many-body entanglement within the atomic array.

Q 28.16 Tue 17:00 Philo 2. OG

Characterisation of perovskite quantum dots interfaced with a high-finesse cavity — •Svenja Müller[1], Amrutha Rajan[2], Gabriele Raino[2], Maksym Kovalenko[2], and David Hunger[1] — [1]Physikalisches Institut, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany — [2]Department of Chemistry and Applied Biosciences, Institute of Inorganic Chemistry, ETH Zurich, 8093 Zurich, Switzerland.

Perovskite Quantum dots (PQDs) exhibit promising optical characteristics like a narrow emission line-width, a strong oscillator strength, and high quantum yield. Interfacing PQDs with an optical cavity gives the possibility controllably enhance light-matter interactions via the Purcell effect. As a first step, we integrate PQDs in a tunable, fiber-based microcavity to realize a highly coherent emitter of single photons. This may enable the generation of indistinguishable photons at room temperature, which can be useful in quantum network experiments. As a second step, we aim to reach the regime of strong coupling by integrating large PQDs with increased oscillator strength into a high-finesse cavity. In the strong coupling regime, the coupling of the emitter to the cavity is faster than the dephasing and cavity decay rates, offering insights into coherent light-matter interactions.

Q 28.17 Tue 17:00 Philo 2. OG

Spontaneous emission in the presence of a hemispherical mirror — •Yannick Weiser, Tommaso Faorlin, Lorenz Panzl, Giovanni Cerchiari, and Rainer Blatt — Universität Innsbruck, Institut für Experimentalphysik, Technikerstraße 25, 6020 Innsbruck, Austria

We control the spontaneous emission of a trapped $^{138}Ba^{+}$ ion by back reflecting the fluorescence light of the ion to itself via a mirror. Due to this retro reflection, the emitted photon interferes with itself, which enhances, or suppresses the observed emission rate, depending on the ion-mirror distance. Previous systems used lenses to guide the fluorescence light to a planar mirror. This approach limits the controllable portion of solid angle. Instead in a new system, called the Panopticon setup, the ion is placed in the center of curvature of a hemispherical mirror with NA = 0.996.

Future experiments enabled by the high-NA control of the mirror will investigate the alteration of the spontaneous emission rate in the presence of the hemispherical mirror. A suppression down to 6% of the natural rate of spontaneous emission is predicted in a realistic scenario. Since this effect on the emission rate is wavelength dependent, the natural branching ratio is influenced by the presence of the hemispherical mirror in a wavelength dependent way.

A hemispherical mirror spanning a large large part of the solid angle may also reshape the spatial distribution of emitted fluorescence light, enabling one to tailor the emission towards a preferred direction.

Q 28.18 Tue 17:00 Philo 2. OG

Spatially-varying spin-photon coupling in the antiferromagnetic Dicke-Ising model — •Anja Langheld and Kai Phillip Schmidt — Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg

The Dicke-Ising model is a paradigmatic model for studying light-matter interactions. For antiferromagnetic Ising interactions, the model reveals a rich quantum phase diagram, including a phase with coexisting antiferromagnetic and superradiant order. However, this phase was found to be notably restricted in its extent, in particular in one dimension [1]. As a potential mechanism to expand this phase, we study spatially-varying spin-photon couplings in the Dicke-Ising model beyond the long-wavelength approximation. For this, we employ a specialized quantum Monte Carlo (QMC) method tailored to Dicke-Spin systems [1], allowing us to accurately pinpoint all quantum phase transitions.

[1] A. Langheld et al., Phys. Rev. B 112, L161123 (2025)

Q 28.19 Tue 17:00 Philo 2. OG

(Quasi-)continuous-wave superradiant Lasers — •Max Hachmann, David Nak, and Andreas Hemmerich — Institut für Quantenphysik, Universität Hamburg, Deutschland

Superradiant Lasers are promising candidates for next-generation light sources with ultralow bandwidth, suitable as read-out tools for passive optical atomic clocks or active frequency standards themselves. Their main advantages are the possible utilization of ultranarrow transitions for lasing and a strongly suppressed dependence on an eigenfrequency of the laser cavity. However, achieving the full potential of sub-natural linewidths requires continuouswave operation, as pulsed emission is Fourier-limited.

We report the successful operation of a quasi-continuously emitting superradiant laser using cold bosonic calcium-40 atoms as the gain medium. These atoms are cooled in a bichromatic magneto-optical trap and loaded into a magic-wavelength one-dimensional optical lattice prepared inside a cavity. After incoherent population of the upper laser state, pulsed superradiant emission on the 370 Hz intercombination line was realized. We extended this scheme to continuously pump the decayed atoms back into the upper laser state, prolonging the lasing by up to three orders of magnitude until too many atoms are lost due to heating. We could observe a Fourier-limited but sub-natural emission linewidth of less than 100 Hz and confirmed suppressed cavity influence with a cavity pulling factor of only 0.5 %.

Q 28.20 Tue 17:00 Philo 2. OG

Optimizing ancilla-assisted shortcuts to adiabaticity — •Giorgio Anfuso[1,4], Emma King[2], Luigi Giannelli[1,3,4], Giuseppe Falci[1,3,4], and Giovanna Morigi[2,5] — [1]Dipartimento di Fisica e Astronomia "Ettore Majorana", Universitá di Catania, Via S. Sofia 64, 95123, Catania, Italy — [2]Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany — [3]CNR-IMM, UoS Universitá, 95123, Catania, Italy — [4]INFN Sez. Catania, 95123 Catania, Italy — [5]Center for Quantum Technologies (QuTe), Saarland University, Campus, 66123 Saarbrücken, Germany

Adiabatic protocols are valued for their intrinsic robustness to control imperfections, but their long evolution times make them susceptible to decoherence. Shortcuts to adiabaticity (STA) describe techniques used to reach the same target states more rapidly, thereby mitigating this exposure to noise. Recent works have shown that STA can be implemented in driven two-level systems by coupling to an ancillary quantum system, achieving substantial suppression of diabatic transitions. We identify further opportunities for performance enhancement in this ancilla-assisted protocol by optimizing the driving, coupling strength, and interaction orientation. By dynamically controlling these time-dependent knobs, we use quantum optimal control methods to determine the extent to which quantum ancillas can be further exploited to improve fidelity, robustness, and overall speed of state transfer. Our results take a step toward better understanding the performance benefits of quantum ancilla-assisted STA and clarify the extent to which optimized schemes can surpass fixed-parameter schemes.

Q 28.21 Tue 17:00 Philo 2. OG

Experimental Control with QUDI towards manipulation of single C-13 nuclear spin — •Michel Wolf, Jeremias Resch, Ioannis Karapatzakis, Wolfgang Wernsdorfer, and David Hunger — Karlsruher Institut für Technologie

Quantum networks depend on an interface between photons and long-lived spin degrees of freedom. A promising platform is the tin-vacancy centers in diamond, which offers long electron spin lifetimes due to its strong spin-orbit coupling. To achieve storage times exceeding the communication time between two nodes, even more long-lived nuclear spin degrees need to be coherently addressed. Both the manipulation of these optically addressable spin-qubits and the implementation of quantum network protocols rely on pulse sequences. Therefore, a practical challenge to overcome is the generation of such pulse sequences efficiently as well as the integration to the experimental control orchestrating the required hardware. In this work, we demonstrate the integration of QUDI as a control framework to realize improved and flexible manipulation of a single C-13 nuclear spin.

Q 28.22 Tue 17:00 Philo 2. OG

Quantum dynamical transitions when the corresponding classical phase space has a separatrix: extension of the QKNH theorem beyond double wells — •Peter Stabel and James Anglin — RPTU Kaiserslautern-Landau, 67663 Kaiserslautern

In classical Hamiltonian systems with a slowly time-dependent parameter, adiabatic approximations break down near a separatrix, where a constant-energy contour splits into separate contours, forcing the system to choose which contour to follow. The Kruskal-Neishtadt-Henrard (KNH) theorem relates the probabilities of such post-adiabatic dynamical transitions to the growth rates of the phase space areas enclosed by the different adiabatic contours. Quantum mechanically, in contrast, adiabaticity can persist at energies where it breaks down classically, through dynamical tunneling. Since the adiabatic and classical limits do not commute, the quantum-classical correspondence for dynamical transitions, where a separatrix is crossed in the classical system, is non-trivial. We recently demonstrated that a quantum version of the KNH theorem (QKNH) holds. We derived the QKNH theorem for a time-dependent double-well system, where the nearly degenerate levels below the potential barrier split due to tunneling through the barrier. We demonstrate that these findings are not restricted to double-well systems. We investigate the dynamical transitions of a general quantum pendulum where the crossings of adiabatic energy levels are avoided due to above-barrier reflection.

Q 28.23 Tue 17:00 Philo 2. OG

Frequency Conversion of Solid-State Sources for Telecom-Band Quantum Networking — •Chao Gao, Fabrice von Chamier Gliszczinski, Elnaz Bazzazi, Roger Alfredo Kögler, Esteban Gomez Lopez, Hala Said, and Oliver Benson — Institut für Physik der Humboldt-Universität zu Berlin

Solid-state quantum emitters are promising systems for quantum communication, yet their emission wavelengths are typically far from the low-loss telecom band required for efficient transmission in quantum networks. Frequency conversion bridges this mismatch. Our previously published two-step architecture (Optics Express 33, 21650 (2025)) provides a low-noise approach for translating photons from efficient non-telecom solid-state emitters toward the telecom regime.

Here, we examine the performance of one stage of that two-step converter–a difference-frequency generation interface in a periodically poled lithium niobate waveguide–designed to be compatible with non-telecom photons from semiconductor quantum dots. We characterize its efficiency and noise behavior. This work provides a frequency-conversion interface that mediates between stationary solid-state emitters and telecom-compatible quantum networks.

Q 28.24 Tue 17:00 Philo 2. OG

Engineering of maximally entangled orbital angular momentum states via path identity — •Richard Bernecker[1,2], Baghdasar Baghdasaryan[3], and Stephan Fritzsche[1,2] — [1]Institute for Theoretical Physics, Friedrich Schiller University Jena, Fröbelstieg 1, 07743 Jena, Germany — [2]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — [3]Institute of Applied Physics, Friedrich Schiller University Jena, Albert-Einstein-Str. 6, 07745 Jena, Germany

Cutting-edge quantum technologies lean on sources of high-dimensional entangled states (HDES) that reliably prepare high-fidelity target states. The idea to overlap photon paths from distinct but indistinguishable sources was recently introduced for the creation of HDES, known as entanglement by path identity. In this regard, the use of orbital angular momentum (OAM) modes is promising, as they offer a high-dimensional and discrete Hilbert space to encode information. While entanglement by path identity with OAM has been verified experimentally, a detailed investigation of how the OAM distribution of photon pairs can be engineered to maximize the entanglement is lacking. We address this gap and identify an optimal dimensionality for maximally entangled states (MESs) when the spatial engineering of the pump beam and the path identity approach are combined. Our theoretical study reveals notable limitations for the fidelity of high-dimensional target states. We also establish the equivalence of entangled biphoton states pumped by a spatially engineered beam and generated via path identity.

Q 28.25 Tue 17:00 Philo 2. OG

Multi-Wavelength Stellar Intensity Interferometry with a Telescope Array — •Iurii Datii[1], Oren Ironi[2], Nick Konidaris[3], Sagi Ben-Ami[2], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, FAU Erlangen, Germany — [2]Weizmann Institute of Science, Rehovot, Israel — [3]Carnegie Observatories, Pasadena, USA

Recent progress in single-photon detection has renewed interest in stellar intensity interferometry. We present a concept for an HBT (Hanbury Brown Twiss) experiment combining a spectrograph with a telescope array to achieve a broad optical bandwidth. The spectrograph minimizes light loss from filtering, while the SPAD Lambda detector (with 320 linearly arranged pixels) covers $\Delta\lambda = 0.2$ nm per pixel, greatly improving the signal-to-noise ratio.

The setup employs twenty 60 cm telescopes, offering a large effective collecting area at about 10% the cost of a single telescope with a diameter of 2.7m. This compact, cost-efficient array enables affordable large-baseline optical intensity interferometry and precise measurements of stellar diameters.

Q 28.26 Tue 17:00 Philo 2. OG

Tomographic reconstruction of free-electron quantum states — •Hao Jeng[1,2] and Claus Ropers[1,2] — [1]Department of Ultrafast Dynamics, Max Planck Institute for Multidisciplinary Sciences, D-37077 Göttingen, Germany — [2]IV. Physical Institute, University of Göttingen, D-37077 Göttingen, Germany

Quantum state tomography is a fundamental and essential technique in every branch of quantum optics, this being true also for the newly emerging field of free-electron quantum optics. In this contribution, we describe several algorithms for reconstructing quantum states of swift electrons, using maximum likelihood estimation, Bayesian inversion, and deep learning. We apply these algorithms to experimental data previously recorded for an attosecond electron pulse-train to retrieve the density matrix and to analyse its physical properties. Based on the reconstructed quantum state, we obtain pulse-durations of about 245as and predict a degree of coherence of 36 per cent for radiations and excitations produced by these electrons.

Q 28.27 Tue 17:00 Philo 2. OG

Hanbury Brown-Twiss interference of electrons in free space — •Florian Fleischmann[1], Mona Bukenberger[1,2], Anton Classen[1,3], Marc-Oliver Pleinert[1], and Joachim von Zanthier[1] — [1]Friedrich-Alexander- Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Freie Universität Berlin, Berlin, Germany — [3]University of Utah, Salt Lake City, USA

We investigate the spatial second-order correlation function of two electrons originating from two nanotips in a Hanbury Brown-Twiss like setup. 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 quantum-mechanical treatment of the problem, where we separate the system into relative and center-of-mass coordinates in analogy to the Hydrogen atom ansatz. While the center-of-mass system is described as a free particle, the relative system contains the Coulomb scattering process which translates into an effective one-particle problem. We expand the respective initial state of the electrons in the eigenstates of the corresponding Hamiltonian and evolve the system in time. After the scattering process, the function is evaluated in the far field. We present the formal solution of the problem and discuss the current state of the numerical investigations.

Q 28.28 Tue 17:00 Philo 2. OG

Towards counterpropagating frequency converters in x-cut TFLN — •Nivedita Vishnukumar, Laura Bollmers, Michael Rüsing, Harald Herrmann, Laura Padberg, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Frequency converters are mainly used to bridge the spectral mismatch between different photonic systems, for example converting wavelengths used for quantum memories to telecom band. Thin-film lithium niobate (TFLN) is a viable platform due its high nonlinear coefficient, high index contrast, and poling capabilities for $\chi2$ nonlinear processes. Conventional frequency converters work on co-propagating interactions, where pump, signal, and idler waves travel in the same direction. Counterpropagating frequency converters are less explored and are particularly interesting because such a process can generate separable quantum states with different bandwidths, eventually being helpful in secure quantum computation. The large phase mismatch from the counterpropagating photons is compensated through quasi phase matching (QPM) and this requires ultrashort poling periods of TFLN in sub-micrometer orders. We investigate through simulation and fabrication the feasibility of implementing counterpropagating frequency converters on x-cut TFLN. Our efforts focus on optimizing device geometry and exploring nanometer-scale poling techniques to enable efficient nonlinear interactions on this platform.

Q 28.29 Tue 17:00 Philo 2. OG

Optimization of electrode design for future interaction-free-measurements with electrons — •FABIAN BAMMES[1], FRANZ SCHMIDT-KALER[1], NILS BODE[1], MICHAEL SEIDLING[1], ROBERT ZIMMERMANN[1], LARS RADTKE[1], JUSTUS WALTHER[1], and PETER HOMMELHOFF[1,2] — [1]Erlangen-Nürnberg (FAU), Staudtstrasse 1, D-91058 Erlangen, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, D-80799 München, Germany

True single particle observation of biological samples at atomic resolution is currently limited by radiation damage and low sample contrasts. Both challenges can be overcome with novel observation techniques established in the optical regime, namely interaction-free measurements (IFM) reducing damage, -and multi-pass experiments optimizing low sample contrast. Transferring detection from photons to charged particles potentially increases lateral resolution. IFM with electrons will be realized in a quantum electron microscope (QEM) employing three individual electron-optical components, namely electron guide, splitter and beam resonator. All three of them have been demonstrated individually with planar electrostatic electrode arrays using the auto-ponderomotive principle. We operated at primary energies of up to 9.5keV for guiding, 1.7keV for splitting and 50eV for resonating electron beams. Current work focuses on deceleration on-a-chip, as well as the geometric optimization to reduce losses and improve the pseudo-potential symmetry.

Q 28.30 Tue 17:00 Philo 2. OG

Bohmian Trajectories in a Double Slit Experiment — •Ozan Nacitarhan[1,2,3], Carlotta Versmold[1,2,3], Florian Huber[1,2,3], Lukas Knips[1,2,3], Jan Dziewior[1,2,3], Eun Mi Kim[1,2,3,4], and Harald Weinfurter[1,2,3] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, München, Germany — [2]Munich Center for Quantum Science and Technology, München, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany — [4]Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea

Bohmian mechanics provides a realist interpretation of quantum mechanics in terms of particles with definite positions, evolving along well-defined trajectories. In turn, this concept requires non-local effects, allowing instantaneous changes of the trajectory due to remote modifications of the setup.

Bohmian trajectories have been reconstructed via weak measurements and have been shown to agree with predicted ones in stationary setups. In our experiment, we record the trajectories of a photon in a double slit interferometer using direct phasefront measurements and additionally implement time-dependent which-way marking and delayed-choice quantum erasure to explore the theory*s non-locality. By initially entangling the double slit photon with a second photon, we are able to analyze the which-way-information and observe changes in the evolution of the interfering photon in dependence on the observation of the second photon. Thereby examining the need and consequences of the non-local mechanism in Bohmian mechanics.

Q 28.31 Tue 17:00 Philo 2. OG

Guiding electrons in rotating saddle potentials — •Franz Schmidt-Kaler[1], Johannes Illmer[1], Fabian Bammes[1], and Peter Hommelhoff[1,2] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, D-80799 München, Germany

We aim at achieving true single particle detection of radiation-sensitive samples by interaction-free measurement (IFM) within a quantum electron microscope (QEM). The principle, already established with photons, can benefit in lateral resolution by switching to electrons. A challenge remains the creation of the required electron-optical elements, namely guide, splitter and resonator. We present a novel guiding concept in which 3D printing enables the creation of rotating saddle potentials. We achieve trap depths of 11eV and show guiding of up to 20keV electrons in simulation and measurement, whilst recording the 1st stability regime. The concept promises simple adoption and could potentially find use in ion trap shuttling, as well as electron optics and localized radiation therapy.

Q 28.32 Tue 17:00 Philo 2. OG

Interaction-induced topological phase transition via spatially selective nonlinearity in photonic honeycomb lattices — •Bashar Karaja, Michael Fleischhauer, and Christina Jörg — RPTU Kaiserslautern, Kaiserslautern, Germany

We study interaction-induced topological phase transitions (IDTPs) in a photonic Haldane[1] lattice with spatially modulated Kerr nonlinearity. By applying nonlinear terms of opposite signs on A and B sublattices, we create an intensity-dependent effective mass term that can lead to local topology changes dynamically with the strength of the optical field. IDTPs appear only when the optical field exceeds specific thresholds: an inverse participation ratio (IPR) $>= 0.004$, indicating sufficient spatial localization of the field, and a population measure p5, defined as the summed intensity on the five brightest sites. Stronger nonlinearity opens a larger induced band gap, increasing the lifetime, the spatial confinement, and the edge-state propagation length of the topological phase. Because the nonlinearity togehther with spatially non-uniform laser intensity breaks lattice periodicity, we characterize local topology using the spectral localizer, which remains valid in strongly inhomogeneous systems. To enhance experimental viability, we propose a pump-probe scheme in which a strong pump beam generates the nonlinear potential and a weak probe excites edge states. Higher pump power yields smoother, more stable effective potentials and longer-lived induced topological phases.

[1]Haldane, F.D. (1988). Model for a quantum Hall effect without Landau levels. Phys. Rev. Lett., 61(18), 2015-2018.

Q 28.33 Tue 17:00 Philo 2. OG

Towards an all-optical phase shifter based on integrated waveguides immersed in hot atomic vapor — •Annika Belz[1], Alexandra Köpf[1,2], Benyamin Shnirman[1,2], Xiaoyu Cheng[1], Hadiseh Alaeian[3], Harald Kübler[1], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Germany — [2]Institut für Mikroelektronik Stuttgart (IMS-Chips), Stuttgart, Germany — [3]Departments of Electrical & Computer Engineering and Physics & Astronomy, Purdue University, West Lafayette, USA

The combination of thermal atomic vapor with nanophotonics provides a unique testbed for the manipulation of atom-photon and atom-atom interactions. While benefitting from strong miniaturization, integration and scalability, we can furthermore enhance the atom-light interaction by engineering the waveguide structures correspondingly.

Using this platform, we want to realize an all-optical phase shifter in the telecom wavelength on the few photon level, which is a fundamental building block for e.g. photonical quantum computing.

This device leverages the effective refractive index change in rubidium for 1529nm light, corresponding to the excitation from the intermediate $5P_{3/2}$ state to the $4D_{5/2}$ state, induced by 780nm light, exciting the atoms from the $5S_{1/2}$ ground state to the $5P_{3/2}$ intermediate state.

We present first free-space measurements using a Michelson interferometer characterizing the three-level system and first designs towards the integration.

Q 28.34 Tue 17:00 Philo 2. OG

Sub-Doppler absorption lines at telecom wavelength in hot ^{87}Rb vapor — •Inna Kviatkovsky[1], Lucas Pache[1], Leonid Yatsenko[2], Viola-Antonella Zeilberger[1], Philipp Schneeweiss[1], Jürgen Volz[1], and Arno Rauschenbeutel[1] — [1]Department of Physics, Humboldt University of Berlin, Berlin, Germany — [2]Institute of Physics, National Academy of Sciences of Ukraine, Kyiv, Ukraine

Room-temperature atomic ensembles for quantum technologies are gaining interest due to their accessibility and reduced experimental complexity. One of the main challenges when working with such ensembles is the Doppler-broadening of the atomic transition frequencies. In this work, we present an approach that mitigates Doppler broadening for the upper transition at telecom wavelength in a three-level ladder scheme in ^{87}Rb. The scheme involves driving the lower transition with a strong pump field at the D2-line wavelength of 780 nm, while a weak counter-propagating field at 1529 nm ($5P_{3/2} \rightarrow 4D_{5/2}$) probes the dressed state. We experimentally demonstrate that absorption features with sub-Doppler width and an enhanced optical depth can be achieved for the probe field. Moreover, the experimental spectra agree well with the predictions of our dedicated theory framework. Achieving sub-Doppler absorption lines together with high optical depth at the technologically relevant wavelength regime of the telecom C-band is highly relevant for applications in optical quantum technologies.

Q 28.35 Tue 17:00 Philo 2. OG

Self-organized transport in noisy dynamic network — Frederic Folz[1], •Joshua Rainer Ganz[1], Sayan Roy[1], Adish Singha[2], Kurt Mehlhorn[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Max-Planck-Institut für Informatik, Saarland Informatics Campus, 66123 Saarbrücken, Germany

We present a numerical study of multicommodity transport in a noisy, nonlinear network. The nonlinearity determines the dynamics of the edge capacities, which can be amplified or suppressed depending on the local current flowing across an edge. We consider network self-organization for different activation functions and types of noise.

We identify parameter regimes where noise leads to self-organization into more robust topologies, that are not found by the sole noiseless dynamics. Moreover, the interplay between noise and specific functional behavior of the nonlinearity gives rise to different features, such as (i) continuous or discontinuous responses to the demand strength and (ii) either single or multistable solutions. Our study shows the crucial role of the activation function on noise-assisted phenomena.