Q 63: Poster – Quantum Information (joint session QI/Q)

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

Q 63.1 Thu 17:00 Tent

Classicality, Markovianity and local detailed balance in isolated quantum systems — •Philipp Strasberg — Instituto de Física de Cantabria (IFCA), Santander, Spain

This poster reviews how the familiar description of stochastic thermodynamics, based on classical Markov processes obeying local detailed balance, emerges from an underlying quantum description from first principles. Here, "first principles" means that we avoid ensemble averages and any assumptions breaking the unitarity of the underlying quantum dynamics (e.g., Born or Markov approximations). Connections to a general approach of thermodynamic entropy (production) and the structure of the Multiverse are also indicated.

Q 63.2 Thu 17:00 Tent

Intensity Stabilization in Fiber Amplifiers: Effects on Phase Noise, Linewidth, and Qubit Coherence — •Jia-Yang Gao, Jasper Phua Sing Cheng, Morteza Ahmadi, and Manas Mukherjee — Centre for Quantum Technologies, National University of Singapore

Intensity noise is a factor limiting the coherence time of qubits in trapped ion quantum systems. Previously, we observed that using a Thulium-doped fiber amplifier (TDFA) introduces intensity fluctuations to the input seed laser, thus limiting the coherence time. To address this issue, we developed an intensity stabilization setup for a 1762 nm laser used for quadrupole transition, employing an acousto-optic modulator (AOM) with an electrical feedback servo. Our results demonstrate that this setup can reduce intensity noise by up to 20 dB from DC to 10 kHz without introducing additional phase noise and broadening the linewidth to the input signal. The phase noise and linewidth of the laser was analyzed using delayed self-heterodyne interferometry (DSHI). We also cross-check the stabilized beam using a single ion in our ion trap setup. Based on the Rabi oscillation results at different power levels, we observe an improvement in coherence time.

Q 63.3 Thu 17:00 Tent

Preparation and Control of Logical Qubits in the Hyperfine Structure of $^{173}Yb^+$ — •Selena-Maria Bota, Monika Leibscher, and Christiane P. Koch — Freie Universität Berlin, Berlin, Germany

Recent research proposes robust encoding of quantum information in high angular momentum atomic or molecular states, where the logical qubits are protected against most common errors [1]. Such codewords can be built in the hyperfine structure of trapped ^{173}Yb$^+$, namely using metastable states in the $^2F^0_{7/2}$ manifold [2]. This work focuses on the preparation of such robust qubits with sequences of microwave pulses. We present a theoretical description of the atom's hyperfine structure and the transitions between hyperfine levels driven by time-dependent magnetic fields. We furthermore simulate the population dynamics driven by sequences of microwave pulses and optimise the pulse sequences in order to excite the desired codewords.

[1] Jain, Shubham P., et al. "Æ codes." arXiv preprint arXiv:2311.12324 (2023).

[2] Xiao, Di, et al. "Hyperfine structure of Yb+ 173: Toward resolving the Yb 173 nuclear-octupole-moment puzzle." Physical Review A 102.2 (2020): 022810.

Q 63.4 Thu 17:00 Tent

Measurable Entanglement lower bounds for Cold Atom Quantum Simulators using kinetic operators — •Maike Reckermann[1], Niklas Euler[1,2], and Martin Gärttner[1] — [1]Institut für Festkörpertheorie und Optik, Friedrich-Schiller-Universität Jena, Deutschland — [2]Physikalisches Institut, Universität Heidelberg, Deutschland

The entanglement dimension plays a key role for understanding quantum many-body phenomena such as topological order, recently realized with cold atoms in lattice geometries. However, for cold atom quantum simulators, determining the entanglement spectrum from measurements is a challenge for experiments as it generally requires the full reconstruction of the quantum state.

Here, we propose a new method to bound the entanglement dimension, which is the number of non-zero values in the spectrum, using the information contained in the measurement of kinetic operators in double wells, which was recently pioneered with ultracold bosonic atoms in a 2D optical lattice. Using also positivity constraints, non-measured elements of the density matrix can be bounded through the fidelity to a reference state, that is optimized in post-processing. We show through numerical simulations, that the entanglement dimension can be lower bound by information form the new measurement operators for a few body system with 2 distinguishable particles in a 1D lattice.

The protocol to bound the entanglement dimension with this measurement method is more efficient than previous methods and could be generalized to a 2D lattice or to create bounds on other observables.

Q 63.5 Thu 17:00 Tent

Polarization Independent Frequency Conversion into the UV — •Katrin Schatzmayr, Anica Hamer, and Simon Stellmer — Rheinische Friedrich Wilhelms Universität Bonn

As the performance of quantum computers grows, quantum networks become more significant. A possible implementation of such a network is a hybrid architecture based on solid state emitters, network nodes, and photons serving as flying qubits. This exchange often requires frequency conversion of the photons while preserving entanglement.

We have successfully developed a polarization-independent frequency conversion setup based on nonlinear crystals that converts photons from the wavelength of a quantum dot at 853 nm (InAs/GaAs) to the wavelength of trapped Yb+ ions at 370 nm.

Q 63.6 Thu 17:00 Tent

Comparative analysis of loan risk forecasting using quantum machine learning and classical machine learning models — •Mohammed Mustapha Adamu[1,2], Peter Nimbe[1], and Abdul Razak Nuhu[1] — [1]Department of Computer Science and Informatics, University of Energy and Natural Resources — [2]Savannah Regional Health Directorate

Non-performing loans present a significant challenge to financial institutions, driven by the complexity of the dataset, default probability, and default correlation(Bellotti et al., 2019). To mitigate this risk, this study investigates the potential of Classical Machine Learning (ML) and Quantum Machine Learning (QML) algorithms for forecasting loan risk. Using a dataset from Kaggle, we conducted a comparative analysis between Support Vector Machine (SVM) and Quantum Support Vector Machine (QSVM). Our result using a dataset of 12,368 records and 12 features shows that the QSVM model outperformed SVM, with a higher true positive rate (93.2.%) and true negative rate (87.6%), demonstrating better performance in identifying both default and non-default cases. Additionally, QSVM exhibits a lower false negative rate indicating its superior ability to minimize clients likely to default. The AUC score of 1.0 for the QSVM further demonstrates its exceptional ability in loan prediction. While the dataset used allowed for a solid comparison, QSVM demonstrated its capacity to continue improving with larger datasets, showing its scalability and strong potential application in loan risk forecasting especially with larger datasets.

Q 63.7 Thu 17:00 Tent

Surgical Procedure Recognition Using Quantum Machine Learning — •Abdul Razak Nuhu[1,2], Peter Nimbe[1], Mohammed Mustapha Adamu[1], and Eliezer Ofori Odei-Lartey[2] — [1]Department of Computer Science and Informatics, UENR, P. O. Box 214, Sunyani, Ghana — [2]Kintampo Health Research Centre, Kintampo, Ghana

Surgical procedure recognition is a critical field in robotic-assisted surgery that focuses on identifying complex surgical tasks like suturing, needle passing, and knot tying. This research explores Quantum Machine Learning (QML) algorithms, specifically the Quantum Support Vector Classifier (QSVC), to analyze surgical gestures more effectively than traditional methods. Using the JIGSAWS dataset with 76 motion characteristics, the study compared QSVC performance against a conventional Support Vector Classifier (SVC) using metrics like accuracy, precision, recall, and F1-score. The results demonstrated that QML-derived models significantly outperform classical machine learning techniques in processing surgical kinematic data. The research suggests that QML has transformative potential in surgical robotics and gesture recognition, particularly as quantum computing advances. By providing more sophisticated analysis of surgical procedures, this approach promises to enhance real-time surgical support, improve medical education, and ultimately develop more context-aware surgical systems that could improve patient care.

Q 63.8 Thu 17:00 Tent

Photon Fusion Analysis with Imperfect Sources — •Ruolin Guan and Klemens Hammerer — Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

Photon fusion, a process integral to various quantum technologies, relies heavily on the availability of high-quality photon sources. However, real-world implementations often contend with imperfect sources, introducing inefficiencies and challenges in optimizing fusion outcomes. We explore theoretical frameworks and practical simulations to quantify the impact of imperfections on fusion success rate and outcomes. This work enhances the reliability of photon fusion in practical scenarios.

Q 63.9 Thu 17:00 Tent

Witnessing quantum memory in dynamics using quantum processors — •Krishna Palaparthy, Charlotte Bäcker, and Walter Strunz — TUD Dresden University of Technology, Dresden, Germany

Quantum simulations on noisy quantum computers can help us understand the role of quantum memory in quantum dynamics, for quantum computations and information processing tasks. To demonstrate local disclosure of quantum memory on the NISQ quantum processors, our simulation makes use of a collision model of sequentially applied two-qubit unitaries realizing the dynamics of a non-Markovian amplitude-damping channel. We investigate the relaxation dynamics and its influence on the entanglement dynamics with ancilla that are crucial for the proof of quantum memory.

Q 63.10 Thu 17:00 Tent

Quantum vs. classical: A comprehensive benchmark study for time series prediction using variational quantum algorithms — •Tobias Fellner[1], David Kreplin[2], Samuel Tovey[1], and Christian Holm[1] — [1]Institute for Computational Physics, University of Stuttgart — [2]Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)

Recently, a wide range of variational quantum algorithms have been proposed for time series processing, promising potential advantages in handling complex sequential data. However, whether and how these quantum machine learning models outperform established classical approaches remains unclear. In this work, we conduct a comprehensive benchmark study comparing a variety of classical machine learning models and variational quantum algorithms for time series prediction. We evaluate their performance on time series prediction tasks of chaotic systems of varying complexity. Our results show that in many cases quantum machine learning models are able to achieve prediction accuracies comparable to classical models. At the same time, we also discuss the current practical value as well as the limitations of variational quantum algorithms for time series forecasting.

Q 63.11 Thu 17:00 Tent

Efficient simulation of microscopic master equations using tensor product states — •Junyi Zhang, André Eckardt, and Alexander Schnell — Technische Universität Berlin

In this work, we address the efficient simulation of global master equations by mapping them to local form. We utilize a novel local Redfield master equation in Lindblad form [1]. By leveraging tensor network methods and quantum trajectory algorithms, we describe steady states and explore transport in boundary-driven systems. Through characterization of the current, we examine how interactions and external fields influence transport properties of an XXZ spin chain in presence of finite-temperature reservoirs. This provides insights into dissipative dynamics in quantum many-body systems. This approach offers a computationally feasible alternative for analyzing large Hilbert spaces without full density matrix propagation, allowing us to extend the applicability of rigoriusly derived master equations in complex quantum systems.

[1] A. Schnell, arXiv:2309.07105 (2023)

Q 63.12 Thu 17:00 Tent

Synchronizing Detector Dead Times to Accelerate Quantum Key Distribution — •Maximilian Mengler, Maximilian Tippmann, and Thomas Walther — TU Darmstadt, Institute for Applied Physics, 64289 Darmstadt

Most Quantum-key-distribution setups consist of photon detection systems with multiple single-photon detectors. Upon measuring a photon these detectors will enter a dead time but due to security reasons only events that are registered when all detectors are ready may contribute to a key for various protocols, e.g. BBM92. This especially constrains systems relying on cheaper detectors like single-photon-avalanche-diodes because of the detectors' long dead times. At high detection rates, two detectors might block each other alternately with one detector entering a new dead time before the other finished its own. We implement a method that utilizes inverse gating signals sent to all detectors upon registration of an incident photon. This leads to the synchronization of the detectors' dead time and ensures that all the detectors are active for the maximum amount of time. We tested this method with our QKD system for various losses between the receiving parties and investigated its effect. In doing so, we were able to increase the secure key rate by up to 75%.

Q 63.13 Thu 17:00 Tent

Implementing post-processing algorithms for a star-shaped quantum key hub — •Tobias Liebmann, Maximilian Tippmann, and Thomas Walther — TU Darmstadt, Institute of Applied Physics, 64289 Darmstadt

The recent advances in quantum computing pose a threat to the security of conventional cryptographic algorithms like the Rivest-Shamir-Adleman (RSA) public key scheme. In particular, Shor's algorithm makes it possible to decode such encryption in polynomial time. Quantum key distribution (QKD) offers a solution to this problem, which not only provides computational security like post-quantum cryptography but information theoretic security. However, to ensure this level of security, the exchanged raw quantum keys must undergo a detailed post-processing procedure. We present recent advances regarding the implementation of the post-processing algorithms on our star-shaped QKD network.

Q 63.14 Thu 17:00 Tent

A quantum-network register assembled with optical tweezers in an optical cavity — •Matthias Seubert[1], Lukas Hartung[1], Stephan Welte[1,2], Emanuele Distante[1,3], and Gerhard Rempe[1] — [1]Max-Planck-Institute of Quantum Optics, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany — [2]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]CFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona, Spain

Quantum networks offer great potential for secure communication, distributed computing, and precision sensing. However, optical losses and errors between distant nodes make quantum information exchange slow and unreliable. One solution is to use more qubits as a register at each node, allowing multiplexed communication and error correction.

We present recent results [1] demonstrating the potential of a platform that integrates optical tweezer arrays with a macroscopic optical cavity for scalable quantum network nodes. By assembling one- and two-dimensional registers of up to 6 atoms, we address each individual atom to generate atom-photon entanglement via vacuum-stimulated Raman adiabatic passages. As the number of qubits in the register increases, the entanglement fidelity remains constant, an indication of scalability. By generating atom-photon entanglement in a multiplexed manner, we achieved a source-to-detection probability of up to $\sim$90% per run. This is an important step towards the deterministic distribution of entanglement in networks.

[1] L. Hartung et al. Science Vol 385, Issue 6705 pp. 179-183 (2024)

Q 63.15 Thu 17:00 Tent

Three axis magnetic field control setup for nitrogen-vacancy color center magnetometry — •Ricky-Joe Plate, Jan Thieme, Bernd Bauerhenne, and Kilian Singer — Experimental Physics I, Institute of Physics, University of Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Nitrogen-vacancy (NV) centers in diamond provide a promising platform for room-temperature quantum sensing and information processing owing to their unique optical and spin properties and precise fabrication methods allowing for photonic structures such as nano pillars [1]. Precise quantum magnetometry requires an accurate and stable adjustment of the external magnetic field. Our solution incorporates a motorized magnetic system that allows for precise angular alignment relative to the NV-axis and offers adjustable magnetic field strengths. The system is engineered to be highly stable against external disturbances, ensuring consistent and reliable operation over extended measurement periods. Additionally, a custom designed algorithm performs optimal alignment of the magnetic field with regard to the NV center axis.

[1] Schmidt, A., Bernardoff, J., Singer, K., Reithmaier, J.P. and Popov, C. (2019), Fabrication of Nanopillars on Nanocrystalline Diamond Membranes for the Incorporation of Color Centers. Phys. Status Solidi A, 216: 1900233.

Q 63.16 Thu 17:00 Tent

Atom-Photon entanglement across a metropolitan network — •Maya Büki[1], Tobias Frank[1], Marvin Scholz[1], Gianvito Chiarella[1], Pau Farrera[1], Pooja Malik[2], Yiru Zhou[2], Florian Fertig[2], Harald Weinfurter[1,2], and Gerhard Rempe[1] — [1]Max-Planck-Institute of Quantum Optics, Garching, Germany — [2]Ludwig-Maximilians-University, Munich, Germany

Building a scalable quantum network is a key challenge in quantum information science. A critical step in this endeavor is the establishment of robust quantum links capable of transmitting entangled quantum states over long distances. Here, we present the successful demonstration of atom-photon entanglement over a distance of 23 km, spanning the Munich metropolitan area. Within this scope, we can efficiently entangle the spin states of Rubidium (Rb) atoms with optical polarization qubits. This experiment addresses critical challenges, including transmission losses through optical fiber, polarisation drifts and noise. By leveraging quantum frequency conversion from $\lambda_{\mathrm{Rb}} = 780$ nm to the telecom band and tailored filtering techniques, we successfully preserved entanglement fidelity over the link. By converting back the wavelength of the photon to 780 nm it might be possible to write the qubit information onto a heralded quantum memory consisting of a Rubidium atom inside two crossed optical fiber cavities [1]. With this goal in mind we made a first but decisive step towards a real world quantum network link within the Munich metropolitan area.

[1] M. Brekenfeld et al. Nat. Phys. 16, 647 - 651 (2020)

Q 63.17 Thu 17:00 Tent

Solving optimization problems on quantum systems. — •Kapil Goswami[1], Rick Mukherjee[1,2], Herwig Ott[3], and Peter Schmelcher[1,4] — [1]The Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Quantum Center, The University of Tennessee, 701 East Martin Luther King Boulevard, Chattanooga, USA — [3]Department of Physics and Research Center OTIMAS, RPTU Kaiserslautern-Landau, Kaiserslautern, Germany — [4]The Hamburg Centre for Ultrafast Imaging, University of Hamburg, Germany

Solving industry-related optimization problems using classical computers is challenging as they are NP-hard. The current quantum computers are characterized by limited qubits, high levels of noise, and imperfect gates. Hence, exploring resource-efficient encoding schemes can lead to practical quantum advantage. These problems are formulated either as a quadratic unconstrained binary optimization (QUBO) or integer programming (IP). Our first work provides a novel framework to solve QUBO problems such as Maximum Cut (Max-Cut) and Maximum Independent Set (MIS) on the Rydberg platform with local-light shifts, providing a favorable scaling of the number of atoms with problem size compared to existing schemes. In our second work, an algorithm is introduced that directly solves an IP problem using a single atom. Specifically, we use multi-levels of a Rydberg atom and selectively transfer the population between the Rydberg manifolds to find the optimal solution. Both of the quantum algorithms utilize quantum optimal control to reach the solution of the problems.

Q 63.18 Thu 17:00 Tent

Generation and characterization of entangled photon source through the spontaneous parametric down conversion — •Chandana Rao Attigadde Shashikirana[1,2,3], Umakant D Rapol[1], and Anindita Bannerjee[2] — [1]Indian Institute of Science Education and Research, Pune, India — [2]Centre for Development of Advanced Computing (CDAC), Pune, India — [3]Department of Computer Science, Paderborn University, Warburger str.100, 33098, Paderborn, Germany

The work is on the generation and characterization of an entangled photon source using a type-1 crossed Beta-Barium Borate (BBO) crystal through spontaneous parametric down-conversion (SPDC), with a focus on understanding the quantum entanglement phenomenon.

Various experimental tests, including the Hanbury Brown and Twiss (HBT) experiment, visibility measurements, the Clauser Horne-Shimony-Holt (CHSH) inequality, and polarization correlation measurements, were conducted to characterize the entangled photon source. Additionally, the quantum state tomography technique was used to reconstruct the density matrix of the entangled photons.

The results show that the source generates entangled, single photons, which violate the Bell inequality as evidenced by the CHSH parameter of 2.629. The concurrence value of 0.708 and linear entropy of 0.244 provide estimates of the degree of entanglement and the noise present in the entangled photons, respectively.

Q 63.19 Thu 17:00 Tent

Multi-Pass Quantum Process Tomography — •Stancho Stanchev and Nikolay Vitanov — Center for Quantum Technologies, Faculty of Physics, Sofia University, James Bourchier 5 blvd., 1164 Sofia, Bulgaria

We introduce a method to enhance the precision and accuracy of Quantum Process Tomography (QPT) by mitigating errors caused by state preparation and measurement (SPAM), readout, and shot noise. Instead of performing QPT on a single gate, we propose applying QPT to a sequence of multiple applications of the same gate. The method involves the measurement of the Pauli transfer matrix (PTM) by standard QPT of the multipass process, and then deduce the single-process PTM by two alternative approaches: an iterative approach which in theory delivers the exact result for small errors, and a linearized approach based on solving the Sylvester equation. We apply the method to CNOT gate tomography, as well as to evaluate the quality of single-qubit composite gates, constructed by composite pulses and compare them to pre-existing gates. We assess the method's performance through simulations on IBM Quantum, using IBM Simulator and real quantum processors.

Q 63.20 Thu 17:00 Tent

Surface-electrode ion trap testing apparatus for the QTZ at PTB — •Marco Bonkowski[1], Sebastian Halama[1], and Christian Ospelkaus[1,2] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, 30167 Hannover — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

One of the main challenges in performing useful quantum computations outside of purely academic interest is the need for a higher number of high-fidelity qubits. Surface-electrode ion traps have the potential to be a suitable solution for this scalability problem. [1] The ongoing research in this field often requires complicated, expensive setups and highly trained personnel which proves to be challenging for smaller facilities. The quantum technology competence center (QTZ) at the Physikalisch-Technische Bundesanstalt will support the industrial development of quantum technology by providing the necessary infrastructure to test and characterize quantum components such as ion traps. Our group has developed a cryogenic ion trap apparatus for trap testing that was first set up at the LUH and will be used to verify the results of the QuMIC project and then will be transferred to the QTZ. Within the QuMIC project highly integrated BiCMOS chips are developed and used for the microwave generation in the microwave near-field approach [2] to control the qubits. We describe the setup of the apparatus and the associated laser system for trapping beryllium ions.

[1] Chiaverini et al., Quantum Inf Comput 5, 419-439 (2005)
[2] Ospelkaus et al., Phys. Rev. Lett. 101, 090502 (2008)

Q 63.21 Thu 17:00 Tent

Continuous-variable QKD with rate-adaptive error correction for the QuNet initiative — •Stefan Richter[1,2], Hüseyin Vural[1,2], Lukas Eisemann[1,2], Jan Schreck[1,2], Kevin Jaksch[1,2], Ömer Bayraktar[1,2], Thomas Dirmeier[1,2], Wenjia Elser[1,2], Dominique Elser[1,2], and Christoph Marquardt[1,2] — [1]Lehrstuhl für Optische Quantentechnologien, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Max-Planck-Institut für die Physik des Lichts, 91052 Erlangen, Germany

Continuous-variable quantum key distribution (CV-QKD) offers a way to establish symmetrically encrypted secure communication over untrusted channels and backed by security proofs not reliant on assumptions of mathematical complexity. Here, we present our progress on implementating a CV-QKD system designed for metropolitan fiber optical links, which was deployed as part of a large-scale technology demonstration in October 2024 for the QuNet initiative. Our approach is based on discrete modulations (DM) of coherent states and optical homodyne detection, with separate and free-drifting sender and receiver lasers. As such, it is similar and widely compatible with modern fiber optical communication techniques. We discuss some of the unique technical challenges associated with deploying our prototype in a larger network, as well as our proposed mitigations. Secret key rates attained with a complete post-processing stack based on fixed rate error correction are contrasted with the results of using a novel rate-adaptive implementation instead, highlighting the practical advantages of the latter.

Q 63.22 Thu 17:00 Tent

What can we learn from the phase of the momentum wave function? — •André Knoll[1], Leon Cohen[2], and Wolfgang Schleich[1] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQST), Universität Ulm, Albert-Einstein-Allee 11, D-89069 Ulm, Germany — [2]Department of Physics, Hunter College of the City University of New York, 695 Park Ave., New York, NY 10065, United States of America

Due to the Born rule of quantum mechanics, the amplitude of the wave function is often emphasized, while the phase is frequently overlooked. However, a closer examination reveals that the phase, particularly when encoded by the Fourier transform of position space, contains critical information about the original wave function. Building on signal processing techniques introduced by Oppenheim et al. in 1981 (Proc. IEEE, 69, 5, pp. 529-541), we adapt and extend these methods to the quantum mechanical framework. In particular, we show that even when we replace the amplitude of the momentum wave function by a constant, the phase of the momentum wave function allows a partial reconstruction of the position wave function. Our findings underscore the fundamental role of the phase in Fourier-based transformations, offering new insights into quantum mechanics and potential applications in quantum information science.

Q 63.23 Thu 17:00 Tent

AQuRA: A software package for simulating quantum computing with continuous variables — •Sebastian Luhn and Matthias Zimmermann — DLR e.V., Institut für Quantentechnologien, Ulm

There are a variety of simulation tools for digital quantum computers based on qubits. However, simulation tools for analog quantum computers based on continuous-variable quantum systems (e.g. the position of a quantum particle) are rare. Indeed, simulating these quantum systems also comes with a huge demand for computational power. Here we present a self-build simulation package that can calculate a huge variety of continuous quantum systems on powerful HPC hardware as well as on a local pc. Our software does support many well-known codes like GKP or cat codes and offers several predefined gates for simulating operations acting on single and multiple quantum systems.

Q 63.24 Thu 17:00 Tent

Spectral Compatibility and Analytical Constraints in Quantum Marginal Problems — •van Dellen Lea, Wyderka Nikolai, Bruss Dagmar, and Kampermann Hermann — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Germany

The compatibility of quantum marginals, or reduced density matrices, is a cornerstone of quantum mechanics, underlying phenomena like entanglement and non-locality. A fundamental variant of this problem concerns the compatibility of spectra, rather than the reduced density matrices themselves. Specifically, given eigenvalues $\vec{\lambda}_{AB}$ and $\vec{\lambda}_{BC}$ for subsystems AB and BC, the task is to determine whether there exists a joint quantum state ρ_{ABC} such that its reduced density matrices $\rho_{AB} = tr_C(\rho_{ABC})$ and $\rho_{BC} = tr_A(\rho_{ABC})$ exhibit these spectra. If such a state exists, the spectra are deemed compatible; otherwise, they are incompatible.

Recently, a hierarchy of semidefinite programs was developed to address this challenge [1]. This hierarchy is complete and provides dimension-free certificates of incompatibility for all local dimensions.

In this work we present additional analytical conditions for spectral compatibility, by solving the second level of the hierarchy. From this, we systematically derive spectral compatibility constraints for multipartite qudit systems and relate them to inequalities of linear entropies.

[1]: F. Huber, N.Wyderka, arXiv:2211.06349

Q 63.25 Thu 17:00 Tent

Super-Heisenberg scaling of the quantum Fisher information using spin-motion states — •Venelin Pavlov and Peter Ivanov — St. Kliment Ohridski University of Sofia, James Bourchier 5 blvd, 1164 Sofia, Bulgaria

We propose a spin-motion state for high-precision quantum metrology with super-Heisenberg scaling of the parameter estimation uncertainty using a trapped ion system. Such a highly entangled state can be created using the Tavis-Cummings Hamiltonian which describes the interaction between a collective spin system and a single vibrational mode. Our method relies on an adiabatic evolution in which the initial motional squeezing is adiabatically transferred into collective spin squeezing. In the weak squeezing regime, we show that the adiabatic evolution creates a spin-squeezed state, which reduces the quantum projective noise to a sub-shot noise limit. For strong bosonic squeezing we find that the quantum Fisher information follows a super-Heisenberg scaling law $\propto N^{5/2}$ in terms of the number of ions N. Furthermore, we discuss the spin squeezing parameter which quantifies the phase sensitivity enhancement in Ramsey spectroscopic measurements and show that it also exhibits a super-Heisenberg scaling with N. Our work enables the development of high-precision quantum metrology based on entangled spin-boson states that lead to faster scaling of the parameter estimation uncertainty with the number of spins.

Q 63.26 Thu 17:00 Tent

Thermodynamic Consistency of Markovian Embeddings of Open Quantum Systems — •Shreesha S. Hegde, Adrian Romer, and Christiane P. Koch — Freie Universität Berlin, Berlin, Germany

The Surrogate Hamiltonian is an approximation method used to simulate open quantum systems [1]. Here, an infinite bath is represented by a surrogate bath made up of a finite number of two-level systems that strongly interact with the system we are interested in. This is then simulated as a closed system. As expected, this model works only for short simulation times before recurrences are seen in the system due to the unitary evolution of the system and the surrogate bath.

The Stochastic Surrogate Hamiltonian is a Markovian embedding technique that improves on this greatly by implementing a stochastic reset of the surrogate modes to their original thermal state. This is done as a way of mimicking the steady thermal state in an infinite bath and allows for extended simulation times [2]. However, implementing this scheme under conditions that are consistent with thermodynamics can be computationally expensive. We aim to achieve an approximate realization of these conditions under which we can still attain a thermodynamically consistent steady state on the system.

[1] Baer et al., J. Chem. Phys. 106, 8862 (1997)
[2] Katz et al., J. Chem. Phys. 129, 034108 (2008)

Q 63.27 Thu 17:00 Tent

Wigner Negativity and Nonclassicality — •Michael E. N. Tschaffon and Matthias Freyberger — Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQST), Universität Ulm, Albert-Einstein-Allee 11, D-89069 Ulm, Germany

The Wigner function is a well-established tool in quantum physics to study quantum states in phase space. It serves as a quantum analogue of a classical probability distribution. However, in contrast to its classical counterpart it can obtain negative values, which are thus naturally associated with nonclassical features, that is, nonclassicality, of the underlying quantum state. The relation between these negative values, i.e., Wigner negativity, and nonclassicality is quantitatively not well understood. For this purpose, we examine Wigner negativity for bipartite states. We show that, using Bell inequalities with a pseudo spin, nonclassical correlations are monotonically related to Wigner negativity. In particular, we separate the part of Wigner negativity contributing to nonclassical correlations from the one already present in single particle nonclassicality. As a consequence, we find that Wigner negativity is not sufficient to have nonclassical correlations.

Q 63.28 Thu 17:00 Tent

Composite pulses for robust ensemble based quantum tokens with Nitrogen Vacancy color centers — •Jan Thieme, Josselin Bernardoff, Ricky-Joe Plate, Bernd Bauerhenne, and Kilian Singer — Experimental Physics I, Institute of Physics, University of Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

We report on both analytical and experimental outcomes related to the application of tailored composite pulses [1] to effectively address ensembles of nitrogen-vacancy color centers within a novel ensemble based protocol for quantum tokens [2]. Utilizing analytical techniques specific to the Rosen-Zener excitation model, we have developed broadband excitation profiles to compensate for experimental fluctuations in resonance frequency and pulse area. This is especially important for a quantum token application with ensembles. These custom pulses are applied using an arbitrary waveform generator to precisely control individual NV color centers [3]. Future work aims to enhance this strategy to further reduce the susceptibility to technical limitations, thereby improving the overall robustness and effectiveness of the protocol [4].

[1] G. T. Genov, D. Schraft, T. Halfmann and N. V. Vitanov, Phys. Rev. Lett. 113, 043001 (2014). [2] K. Singer, C. Popov,B. Naydenov, Verfahren zum Erstellen eines Quanten-Datentokens (DE 10 2022 107 528 A1) DE-Patent (2023) [3] A. Schmidt, J. Bernardoff, K. Singer, J. P. Reithmaier and C. Popov, Physica Status Solidi A, 216, 1900233 (2019). [4] G. T. Genov, M. Hain, N. V. Vitanov, and T. Halfmann, Phys. Rev. A, 101, 013827(2020)

Q 63.29 Thu 17:00 Tent

Efficient tensor network simulation of open quantum systems with realistic environments — •Matteo Garbellini, Valentin Link, and Walter Strunz — Institut für Theoretische Physik, Technische Universität Dresden, D-01062, Dresden, Germany

We utilize novel numerical techniques for open quantum systems in order to simulate qubit dynamics in experimentally realized quantum devices. Our approach is based on a recently introduced tensor network based method that efficiently generates auxiliary environments for non-Markovian Gaussian baths [1]. In this framework, the combination of multiple noise sources still has exponential scaling. We overcome this issue by employing a matrix product state representation for the system-and-bath degrees of freedom and then performing real-time evolution via TEBD. As an example problem we consider a recent experiment where a Landau-Zener sweep was performed in a superconducting flux qubit [2]. By carefully taking into account both transverse and longitudinal noise, we reach excellent quantitative agreement with the experimental data over large parameter regimes.

[1] Link, V., Tu, H.H., & Strunz, W. Open Quantum System Dynamics from Infinite Tensor Network Contraction. Phys. Rev. Lett., 132, 200403 (2024)

[2] Lupascu, A. et al. Dissipative Landau-Zener tunneling: crossover from weak to strong environment coupling, arXiv:2207.02017v1 (2022)

Q 63.30 Thu 17:00 Tent

Blind Grover Search for Gate-based Quantum Computers — •Alexander Sauer[1], Alexander von Consbruch[2], and Matthias Zimmermann[1] — [1]DLR e.V., Institute of Quantum Technologies, Ulm — [2]University of Göttingen

While quantum computers might offer several computational benefits, their application within a quantum network is also of interest in regard to privacy, data protection and computational security. One promising application is blind quantum computing, where a client with limited quantum capacities utilizes the computational power of a quantum computer located at a quantum computing center without revealing any information about the computation or data involved. Several schemes for blind quantum computation have emerged, with the most advanced relying on measurement-based quantum computing [1]. However, many current quantum computer designs are based on gate-based state manipulation. While blind quantum computing is also possible in this scenario, it requires a permanent exchange of quantum information between client and server [2]. To reduce the communication overhead for the involved parties, we study a relaxed scenario of blind quantum computing, where the server gets some information about the algorithm. In particular, we propose a protocol to hide an n-qubit Grover search algorithm by utilizing additional qubits on a quantum server which are initialized by the clients.

[1] Fitzsimons, J. F. (2017), npj Quantum Information, 3(1), 23.

[2] A. Childs, A. (2005), Quantum Inform. Comput., 5, 456-466.

Q 63.31 Thu 17:00 Tent

Metrology for magnetic moments in transmission electron microscopes — •Michael Gaida[1], Santiago Beltran Romero[2,3], Stefan Nimmrichter[1], Dennis Rätzel[4], and Philipp Haslinger[2,3] — [1]Universität Siegen, Adolf-Reichwein-Straße 2a, 57076 Siegen, Deutschland — [2]Atominstitut, TU Wien, Stadionallee 2, 1020 Vienna, Austria — [3]University Service Centre for Transmission Electron Microscopy, TU Wien, Wiedner Hauptstraße 8-10/E057-02, 1040 Wien, Austria — [4]ZARM, Unversität Bremen, Am Fallturm 2, 28359 Bremen, Germany

In transmission electron microscopy (TEM), an electron beam passes through a thin sample layer, producing an interference pattern that reveals atomic-scale structures. While TEM is well-established, quantum metrology offers potential enhancements. Building on the experimental proposal in reference [1], which aims to detect individual quantum spins' magnetic moments using electron beams, we extend the analysis to include scattering dynamics in the paraxial high-energy regime. We calculate the quantum Fisher information for estimating magnetic moments using analytical and numerical methods, comparing it to classical methods with position-resolving electron detectors. Our goal is to determine the experimental conditions required to detect a single Bohr magneton with focused electron beams.

[1]P. Haslinger, S. Nimmrichter, and D. Rätzel, Spin resonance spectroscopy with an electron microscope, QST 9, 035051 (2024).

Q 63.32 Thu 17:00 Tent

Scalable, high-fidelity all-electronic control of trapped-ion qubits — •Clemens Löschnauer, Jacopo Mosca Toba, Amy Hughes, Steven King, Marius Weber, Raghavendra Srinivas, Roland Matt, Rustin Nourshargh, David Allcock, Chris Ballance, Clemens Matthiesen, Maciej Malinowski, and Thomas Harty — Oxford Ionics, Oxford, United Kingdom

The central challenge of quantum computing is implementing high-fidelity quantum gates in a scalable fashion. Our all-electronic qubit control architecture combines laser-free gates with local tuning of electric potentials to enable site-selective single- and two-qubit operations in multi-zone quantum processors. Chip-integrated antennas deliver control fields common to all qubits, while voltages applied to local tuning electrodes adjust the position and motion of ions in each zone, thus enabling local coherent control. We experimentally implement low-noise, site-selective single- and two-qubit control in a microfabricated 7-zone ion trap, demonstrating 99.99916(7)% fidelity for single-qubit gates, and two-qubit Bell state generation with 99.97(1)% fidelity. These results validate the path to directly scaling these techniques to large-scale quantum computers based on electronically controlled trapped-ion qubits.

Q 63.33 Thu 17:00 Tent

Towards a real-time controlled cryogenic eight qubit quantum processor — •Erik Dunkel[1], Kevin Rempel[1], Sebastian Halama[1], Celeste Torkzaban[1], and Christian Ospelkaus[1,2] — [1]Leibniz Universität Hannover, Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

Ions confined by surface-electrode Paul traps represent a promising technology for quantum computing and quantum simulation. In our group, the qubits are encoded in two hyperfine levels of $^{9}Be^{+}$ ions and controlled by trap-integrated microwave conductors, which allow us to manipulate both the internal and motional states of the ions.

We will implement a cryogenic linear ion-trap array for eight ions with all electrical supplies necessary to apply microwave currents, DC- and RF-voltages. The trap array allows linear transport of ions, features independent storage zones and a detection register.

In addition, we will report on the status of the ongoing future-proof upgrade to the ARTIQ control system. This enables nanosecond timing pulse generation, radio-frequency synthesis and data acquisition executed on a dedicated FPGA hardware and interfaced with a Python-based programming language.

Q 63.34 Thu 17:00 Tent

Mitigation of longitudinal electric field components in a tweezer-sized standing-wave optical dipole trap — •Florian Fertig[1,2], Pooja Malik[1,2], Yiru Zhou[1,2], Chengfeng Xu[1,2], and Harald Weinfurter[1,2,3] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Long coherence times are vital for large-scale quantum networks to distribute high-quality entanglement. Single atoms, trapped optically in an optical dipole trap (ODT), with an efficient light-matter interface for atom-photon entanglement have shown to be an excellent system for future quantum nodes. However, dephasing from fluctuations of external magnetic fields, but also effective magnetic fields arising from longitudinal electric field components in tightly focused tweezer beams (beam waist $w_0 \approx 2\mu m$), currently limit the coherence time.

Here, we present the successful implementation and characterization of a novel, tweezer-sized standing-wave ODT for single neutral atoms. This trap geometry effectively mitigates these effective magnetic fields. By overlapping two counterpropagating ODT beams, we create a standing wave, where the effective magnetic fields from each beam cancel each other out. Our measurements confirm the significant reduction of longitudinal field components, resulting in an increase in coherence time. Additionally, this trap architecture holds potential for multiplexing applications, offering a pathway to higher entanglement rates and enhanced quantum processing capabilities.

Q 63.35 Thu 17:00 Tent

Integration of 3D glass structures for scalable trapped-ion quantum computing — •Victoria Schwab[1,2], Klemens Schueppert[2], Max Glantschnig[2,4], Alexander Zesar[2,5], Adrian Woyke[2,6], Philipp Hurdax[3], Bernhard Lamprecht[3], Marco Valentini[1], Marco Schmauser[1], and Philipp Schindler[1] — [1]Institute for Experimental Physics, Innsbruck, Austria — [2]Infineon Technologies Austria AG, Villach, Austria — [3]Johanneum Research Materials, Weiz, Austria — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [5]Karl-Franzens Universität Graz, Graz, Austria — [6]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Trapped-ion quantum computing is one of the most promising platforms in quantum information processing, where qubits are realized as energy levels of single ionized atoms. The preparation, manipulation and read out of the states are driven by laser light, requiring the implementation of optical access into the ion trap.

We present the fabrication route of an ion trap with multiple metal layers on a structured glass substrate. In cooperation with Johanneum Research, the glass substrate is structured by employing a selective laser etching technique, such that it allows additional optical access through the backside of the trap and thus higher flexibility in the laser setup. At Infineon Technologies in Villach, the implementation of the fabrication flow for multi-metal deposition is realized. Future steps include the prototype testing and development of the high optical access laser setup, contributing to making scalable ion traps a reality.

Q 63.36 Thu 17:00 Tent

Observing Product of Weak Values — •Vinay Tumuluru[1,2,3], Jan Dziewior[1,2,3], Carlotta Versmold[1,2,3], Florian Huber[1,2,3], Lev Vaidman[4], and Harald Weinfurter[1,2,3] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, 80797 München — [2]MPI für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching — [3]Munich Center for Quantum Science and Technology (MCQST), 80797 München — [4]Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University, Israel

When a quantum system which was weakly coupled to a measuring 'pointer' system is suitably pre- and post-selected, one can observe a large shift in the state of the pointer. This shift is characterised by the 'weak value' of the pre- and post-selected system [1]. Weak values can be realised via optical interferometers where the path degree of freedom (system) is coupled with the transverse mode of the optical beam (pointer) [2]. Additionally, the polarisation degree of freedom can instead be employed as the system and coupled to the same pointer. This enables multiple systems to interact with the pointer individually and simultaneously. Interesting cases are explored, such as when weak values corresponding to each interaction are complex, but their product is real. Furthermore, a potential entanglement between the observed degrees of freedom can in turn lead to the violation of the product rule of weak values [3]. Ref: [1] Y. Aharonov et al, PRL. 60, 1351 (1988) [2] P. B. Dixon et al, PRL. 102 (2009) [3] X. Xu et al, PRL. 122, 100405 (2019)

Q 63.37 Thu 17:00 Tent

Range of operation and oversqueezed regime of squeezing transfer as means of generating spin-entangled states in trapped ions — •Nadezhda Markova — Center for Quantum Technologies, Department of Physics, Sofia University, Bulgaria

A state is regarded as both squeezed along the direction $\vec{n}_3$ and entangled when the parameter $\xi^2(\vec{n}_3) < 1$ [2]. A necessary and sufficient condition for entanglement is given by $\chi^2 = \frac{N}{F_Q} < 1$ [2], where F_Q is the QFI.

We calculate and compare these parameters for a spin-entangled state in an ion trap. The state in question is generated by transferring squeezing from the motional to the spin degree of freedom. This is achieved by applying the Tavis-Cummings Hamiltonian for a particular time and results in a nonclassical spin state [1].

We compare the parameters ξ^2 and χ^2 as a function of the squeezing parameter r and the number of ions N by simulating the system's evolution using the QuTip library. We identify the oversqueezed regime and the range of operation of the aforementioned procedure.

[1] R. J. Lewis-Swan, J. C. Zu*niga Castro, D. Barberena, and A. M. Rey. Exploiting nonclassical motion of a trapped ion crystal for quantum-enhanced metrology of global and differential spin rotations. Phys. Rev. Lett.

[2] L. Pezzé and A. Smerzi. Entanglement, nonlinear dynamics, and the Heisenberg limit. Phys. Rev. Lett.

Q 63.38 Thu 17:00 Tent

Consistent Strong-Coupling Quantum Master Equations from Dynamical Maps — •Anton Braun, André Eckardt, and Alexander Schnell — Technische Universität Berlin, Institut für Theoretische Physik

One of the most basic quantum master equations describing the interaction between a quantum system and its environment is the Redfield equation. It is, however, well known that it violates complete positivity and leads to incorrect steady states for non-weak coupling. Following up on work by Becker et al. [1], modifications to the Redfield equation are investigated that combat these issues by introducing a correction term that steers the dynamics towards the correct steady state. To this end, we study the exact solution of the Caldeira-Leggett model and show that the corresponding dynamical map can be obtained by combining Redfield theory with ideas from the formalism of periodically refreshed baths. In this way, divergence of the Redfield dynamical map for long times is cured by instead recursively evolving to a shorter time. Finally, the correction term of Ref. [1] can then be recovered from the so-obtained dynamical map. This gives a completely novel perspective on the long-standing issues of the Born-Markov approximation.

[1] Phys. Rev. Lett. 129, 200403 (2022)

Q 63.39 Thu 17:00 Tent

Quantum algorithms to solve partial differential equations in battery modelling — •David Steffen[1,2], Albert Pool[1,2], Michael Schelling[1,2], and Birger Horstmann[1,2,3] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Wilhelm-Runge-Str. 10, 89081 Ulm — [2]Helmholtz Institute Ulm, Helmholtzstr. 11, 89081 Ulm — [3]Department of Physics, Ulm University, Albert-Einstein-Allee 11, 89081 Ulm

Mathematical models of electrochemical systems as batteries or fuel cells consist of sets of coupled nonlinear partial differential equations. We present variational quantum algorithms to simulate these systems on a quantum computer. The spacetime solution can be obtained as the ground state of a Feynman-Kitaev Hamiltonian evaluated via quantum nonlinear processing units (QNPUs) [1] or the system is encoded through feature maps and solved with Differentiable Quantum Circuits (DQC) [2].

These algorithms can be used on different scales from continuum modelling on cell level to molecular dynamics and thus bridging the gap to quantum chemistry which is another promising field of quantum computing in battery research.

[1] Pool, A.J. et al, Phys. Rev. Res. 2024, 6, 033257

[2] Kyriienko, O. et al., Phys. Rev. A 2021, 103, 052416

Q 63.40 Thu 17:00 Tent

The role of the zero mode on the entanglement dynamics of harmonic chains — •Stefan Aimet[1] and Spyros Sotiriadis[2] — [1]Freie Universität Berlin, Berlin, Germany — [2]University of Crete, Heraklion, Greece

In this submission, we investigate the role of a special zero mode feature on the evolution of entanglement under global quench dynamics of harmonic chains.

Q 63.41 Thu 17:00 Tent

Quantum robustness of the toric code in a parallel field on the honeycomb lattice — •Viktor Kott, Matthias Mühlhauser, Jan Alexander Koziol, and Kai Phillip Schmidt — Chair of Theoretical Physics V, Friedrich-Alexander-Universität, Erlangen, Germany

We study the quantum robustness of topological order in the toric code on a honeycomb lattice under a uniform parallel field. For a field in the z-direction, the system maps to the transverse-field Ising model on the honeycomb lattice, showing a second-order quantum phase transition in the 3D Ising* universality class. A positive x-field similarly maps to a ferromagnetic transverse-field Ising model on the triangular lattice, with the same phase transition. In contrast, a negative x-field maps to a frustrated antiferromagnetic model, leading to a 3D XY* transition and a first-order transition to a polarized phase at higher field values. These findings, confirmed by quantum Monte Carlo and series expansions, apply to both honeycomb and triangular lattices, revealing critical behaviors and potential multi-critical points.

Q 63.42 Thu 17:00 Tent

Householder reflections in the Hilbert space of ions trapped in Paul trap — •Vasil Vasilev and Nikolay Vitanov — Department of Physics, Sofia University, James Bourchier 5 boulevard, 1164 Sofia, Bulgaria

This work investigates the ways of generating Householder reflections in the Hilbert space of ions trapped in Paul trap. The Householder reflection is a powerful approach for matrix manipulation in classical data analysis. Here we explore its use in quantum information processing for the creation of arbitrary unitary matrices. In previous publications, an arbitrary Householder transformation is produced either by using different couplings in an N-pod system, for which, however, the Hilbert space is non-scalable [1], or in a scalable Hilbert space but for equal couplings [2,3]. Here we discuss the more general situation of constructing Householder reflections with different couplings in a scalable Hilbert space. The ultimate objective is to construct C^n-phase gates which can be used as native implementations of Householder reflections and hence for efficient decomposition of unitary matrices. The proposed concept can also be used for physical synthesis of arbitrary random matrices. We explore their Haar measures and present a comparison with the Givens rotations method.

[1] Peter A. Ivanov and Nikolay V. Vitanov Phys. Rev. A 77, 012335

[2] Peter A. Ivanov, Nikolay V. Vitanov and Martin B. Plenio Phys. Rev. A 78, 012323

[3] S. S. Ivanov, P. A. Ivanov, I. E. Linington, and N. V. Vitanov Phys. Rev. A 81, 042328

Q 63.43 Thu 17:00 Tent

Onset of Quantum Thermalization in Jahn-Teller model. Stochasticity in ergodic quantum systems. — •Yoana Chorbadzhiyska and Peter Ivanov — Sofia University, Sofia, Bulgaria

In the present work, we investigate the onset of quantum thermalization in a system governed by the Jahn-Teller Hamiltonian which describes the interaction between a single spin and two bosonic modes. We find that the Jahn-Teller model exhibits a finite-size quantum phase transition between the normal phase and two types of super-radiant phase when the ratios of spin-level splitting to each of the two bosonic frequencies grow to infinity. We test the prediction of the eigenstate thermalization hypothesis (ETH) in the Jahn-Teller model. We validate the diagonal part of the hypothesis utilizing various measures. Further, we focus on the statistical properties of the off-diagonal matrix elements and consider an alternative indicator for the validity of this aspect of the ETH. We discuss briefly the theory behind the derivation of the indicator and comment on the application of this theory to the quantum parameter estimation in ergodic systems.

Q 63.44 Thu 17:00 Tent

Characterization and mitigation of optical side-channels in QKD — •Evelyn Edel[1], Moritz Birkhold[1,2], Lukas Knips[1,2,3], Sebastian Melik[4], and Harald Weinfurter[1,2,3] — [1]Ludwig Maximilian University, Munich, Germany — [2]Munich Center for Quantum Science and Technology, Munich, Germany — [3]Max Planck Institute of Quantum Optics, Garching, Germany — [4]University of Gdańsk, Gdańsk, Poland

Unlike classical key distribution methods reliant on computationally hard problems, quantum key distribution (QKD) achieves information-theoretic security by the principles of quantum mechanics. The decoy-state BB84 protocol offers a practical scheme for realizing free-space QKD sender modules, allowing the use of highly attenuated laser pulses as a photon source. Yet, device imperfections could make side channel attacks by an eavesdropper possible. This work presents a characterization of spectral side channels in our sender module, arising from imperfect spectral overlap. For pulse generation, the module under investigation hosts four vertical-cavity surface-emitting lasers (VCSELs) in a monolithic array, one for each polarization state. Using a spectrometer also in combination with a streak camera, we analyze the spectral behavior and time-dependent variations of these diodes for different bias and modulation currents. To minimize the resulting side channels, Peltier modules are tested for cooling individual diodes. This setup will allow us to identify VCSEL arrays with the best spectral overlaps and quantize the information leaked to an eavesdropper, facilitating the future optimization of our modules.

Q 63.45 Thu 17:00 Tent

Quantum search with resetting — •Sayan Roy, Emma King, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D- 66123 Saarbrücken, Germany

Search problems are prevalent in science and nature. Algorithms incorporating resetting mechanisms, where the system randomly or periodically resets to its initial state, have demonstrated improved efficiency in search tasks within both classical and quantum domains [1]. In this contribution, we consider resetting protocols for quantum walks in one dimension with nearest-neighbor hopping and determine the time the walker needs to reach a given target for different implementations of the resetting procedure. We then discuss how the results may be generalized to lattices of higher dimensions and different site connectivity.

[1]. M.R. Evans, S.N. Majumdar and G. Schehr, J. Phys. A: Math. Theor. **53**, 193001.

Q 63.46 Thu 17:00 Tent

Off-resonant dipole-phonon interaction for quantum information processing with molecular rotors — •Leonel O. Stenkhoff, Monika Leibscher, and Christiane P. Koch — Freie Universität Berlin

Encoding quantum information in molecular ions requires a mechanism allowing for cooling and control of rotational quantum states. To this end, the dipole-phonon interaction of molecular and atomic ions co-trapped in a linear Paul trap is utilized. Resonant dipole interaction occurs when the rotational energy splitting is comparable to the eigenfrequency of a normal mode of the trap. Off-resonant dipole-phonon coupling scales with the trap frequency and the dipole moment of the molecule and can become the dominant part of the interaction if the molecule has a particular large dipole moment, as we demonstrate for the example of a trapped cytochrome complex. The prospects of cooling rotational quantum states via off-resonant dipole coupling are also discussed, which is particularly interesting for systems, where no resonant dipole-phonon interaction is observed in the range of achievable trap frequencies.

Q 63.47 Thu 17:00 Tent

Pulse shaping strategies: smooth sine-based pulses for enhanced stability and super power broadening with two tunable types of pulses — •Ivo Mihov and Nikolay Vitanov — Center for Quantum Technologies, Department of Physics, Sofia University, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

This study explores two approaches to pulse shaping for qubit dynamics. First, smooth sine pulses are investigated as alternatives to rectangular pulses, minimizing power broadening, reducing sidebands, and avoiding truncation issues. Two analytic solutions, based on Weber's parabolic cylinder functions and a simplified asymptotic approach, are derived and validated on IBM Quantum processors, confirming the predicted effects.

In contrast, the study also examines two novel pulse families designed to enhance power broadening, creating "super power broadening." These pulse shapes – quadratic and even-power pulses – amplify non-adiabaticity at the pulse edges, enabling more sensitive interactions for applications such as EIT, quantum tomography, and nonlinear optics. These pulse shaping strategies, tested on IBM Quantum processors, offer new tools for optimizing quantum state manipulation, broadening interaction frequencies, and improving spectroscopy techniques.

Q 63.48 Thu 17:00 Tent

Simulating Chemistry with Fermionic Optical Superlattices — •Jin Zhang[1], Fotios Gkritsis[2], Daniel Dux[3], Naman Jain[1], Christian Gogolin[2], and Philipp Preiss[1,4] — [1]Max Planck Institute for Quantum Optics, Garching — [2]Covestro Deutschland AG, Leverkusen — [3]Physikalisches Institut der Universitat Heidelberg — [4]Munich Center for Quantum Science and Technology, Munich

Computational chemistry requires finding the ground states of strongly correlated electrons in molecular orbitals. Quantum algorithms and computers promise to provide such ground state energies for molecular systems whose size is beyond the reach of classical numerical methods. One approach is to translate molecular structure problems to fermionic quantum simulators, which naturally obey the fermionic exchange symmetries found in nature. We show that quantum number preserving

Ansatze for variational optimization in quantum chemistry find an elegant mapping to ultracold fermions in optical superlattices. Using native Hubbard dynamics, trial ground states of molecular Hamiltonians can be prepared and their molecular energies measured in the lattice. The scheme requires local control over interactions and chemical potentials and global control over tunneling dynamics, but foregoes the need for shuttling operations or long-range interactions. Our work enables the application of recent quantum algorithmic techniques, such as Double Factorization and quantum Tailored Coupled Cluster, to present-day fermionic optical lattice systems with significant improvements in the required number of experimental repetitions. We provide detailed quantum resource estimates for hardware experiments.

Q 63.49 Thu 17:00 Tent

Sparse Optimization of Quantum Fourier Transform Spectroscopy — •Chinmay Sangavadekar[1], Zhengjun Wang[1,2], and Frank Schlawin[1,2,3] — [1]University of Hamburg, Luruper Chaussee 149, Hamburg, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

Nonlinear interferometers are of fundamental importance for quantum-enhanced photonic sensing. They enable sensing in the infrared regime at low photon flux and without the need of detecting infrared photons. Here we present a theoretical model for quantum Fourier transform spectroscopy with nonlinear interferometers. We further explore how sparse optimization may reduce the necessary number of measurements and thereby speed up data acquisition.

Q 63.50 Thu 17:00 Tent

Modeling spin initialization in highly strained silicon-vacancy centers — •Michael Gstaltmeyr, Marco Klotz, Andreas Tangemann, and Alexander Kubanek — Institute for Quantum Optics, University Ulm, Germany

Spin qubits in solid state hosts are, due to their promise of scalability, candidates for the realization of quantum networks. The good spin properties of diamond paired with the optical properties of group-IV defects make them of special interest. We are using highly strained Silicon-Vacancy centers in nanodiamonds to mitigate phonon induced electron spin dephasing at liquid helium temperature. However, high strain introduces challenges in optical spin initialization, as additional transitions closely interact with the initialization pathway, complicating the traditional three-level pump model. This work explores these interactions and proposes improved methods to characterize the system.

Q 63.51 Thu 17:00 Tent

Quantum Generative Modelling with Conservation Law based Pretraining — •Akash Malemath[1,2], Yannick Werner[3], Paul Lukowicz[1,3], and Maximilian Kiefer-Emmanouilidis[1,2,3] — [1]Department of Computer Science and Research Initiative QCAI, RPTU, Kaiserslautern-Landau — [2]Department of Physics, RPTU, Kaiserslautern-Landau — [3]DFKI Kaiserslautern

Abstract:

Compared to the recent advancements in classical generative AI, quantum generative models still lack the capability to generate complex data effectively. One of the greatest challenges in classical AI is developing systems that extract fundamental relationships from large datasets and encode them into suitable embeddings. In quantum generative AI, these concepts are still in early stages and are mostly learned using classical methods.

In this work, we evaluate embeddings inspired by conservation laws as a pretraining step, applying them to simple quantum generative models like the Quantum Circuit Born Machine (QCBM). This implicit generative model is well-suited for reproducing target distributions and is simple enough to demonstrate the benefits of pretraining. Specifically, we explore pretraining using the particle number distribution and system Hamiltonian within the QCBM, aiming to model target distributions with reduced effort. Our analysis of pretraining in QCBM focuses on its impact on model convergence and accuracy, using metrics such as Kullback-Leibler (KL) divergence, and compares pretrained models with those trained normally.

Q 63.52 Thu 17:00 Tent

Cluster-additivity of perturbative discrete product of unitaries and applications to the variational quantum eigensolver — •Max Hörmann, Harald Leiser, Sumeet Sumeet, and Kai Phillip Schmidt — Chair for Theoretical Physics V, FAU Erlangen-Nürnberg, Germany

We explore the cluster-additivity properties of a perturbatively defined unitary transformation $U = U_1 \cdot \ldots \cdot U_n$, where each successive order in perturbation theory introduces an additional unitary operator U_n [1]. We establish connections to continuous unitary transformations and compare this approach with globally defined transformations, such as the projective cluster-additive transformation [2]. Furthermore, we emphasize the striking parallels between this transformation and ansätze commonly employed in the variational quantum eigensolver algorithm. Building on this, we propose a variational extension of the transformation, expanding its applicability beyond the perturbative framework. Finally, we assess whether this transformation can effectively construct good initial guesses for larger systems by leveraging information from smaller subsystems.

[1] N. Datta, J. Fröhlich, L. Rey-Bellet and R. Fernández, Low-temperature phase diagrams of quantum lattice systems. II. Convergent perturbation expansions and stability in systems with infinite degeneracy, Helv. Phys. Acta 69(5-6), 752 (1996).

[2] M. Hörmann and K. P. Schmidt, Projective cluster-additive transformation for quantum lattice models, SciPost Phys. 15, 097 (2023).

Q 63.53 Thu 17:00 Tent

Employing Two-Photon Interference to Secure QKD Against Optical Side Channels — •Franziska Divkovic[1], Moritz Birkhold[1,2], Harald Weinfurter[1,2,3], and Lukas Knips[1,2,3] — [1]Ludwig Maximilian University, Munich, Germany — [2]Munich Center for Quantum Science and Technology, Munich, Germany — [3]Max Planck Institute of Quantum Optics, Garching, Germany

Quantum Key Distribution (QKD) provides a key advantage over classical cryptography by enabling secure communication without the risk of unnoticed eavesdropping on the quantum channel. However, in real devices, side channels - additional degrees of freedom (DOFs) correlated with the one used to encode the key - can allow eavesdroppers to extract information. If not quantified, these side channels can compromise the security of the QKD scheme.

A key assumption in the security proof is the phase randomization of consecutive pulses representing the same symbol. Indistinguishable pulses, which are phase-randomized, prevent attacks by ensuring no information can be extracted from alternate DOFs. To verify whether this criterion is met, the interference of these pulses is investigated. Additionally, the interference of pulses representing different symbols is analyzed to assess their indistinguishability across all except polarization. The visibility of the interference pattern serves as a key metric for quantifying pulse indistinguishability and security. This is achieved using a fiber-based interferometer with a delay line in one arm and a polarization-cleaning mechanism. This research provides insights for defining specifications and developing tests to secure against attacks.

Q 63.54 Thu 17:00 Tent

Robust VECSEL for Controlling trapped Magnesium Ions — •Tobias Spanke, Lennart Guth, Philip Kiefer, Lucas Eisenhart, Deviprasath Palani, Apurba Das, Florian Hasse, Jörn Denter, Mario Niebuhr, Ulrich Warring, and Tobias Schätz — Physikalisches Institut, Albert-Ludwigs-Universität, Freiburg

Trapped ions present a promising platform for quantum simulations and quantum sensing. Versatile and robust laser systems with narrow bandwidth and high power and intensity stability are required at UV range of 280 nm to reliably load and control this platform. The latest systems for Mg^+, Be^+ ions are based on vertical external cavity surface-emitting lasers (VECSEL) [1] in the near-infrared. A new generation of air-cooled systems is proposed to decrease bandwidth and increase stability while mitigating expensive temperature control systems. With the goal of measuring magnesium ions at a frequency stability of 200 kHz ($\lambda \approx 1120$ nm, P = 2 W with $\lambda \approx 280$ nm at the experiment) with high accuracy. We aim at further development of the VECSEL into a compact, stable, and user-friendly "turnkey" system.

[1] Burd, S. et al.(2016), VECSEL systems for generation and manipulation of trapped magnesium ions, Optica Vol. 3, Issue 12, pp. 1294-1299 (2016)

Q 63.55 Thu 17:00 Tent

Complexity: chaos, regular, and complex — •Adisorn Panasawatwong, Jan-Michael Rost, and Ulf Saalmann — MPI-PKS

We are developing a machine learning-based approach to extract meaningful information from noisy physical observables. Distinguishing signal from noise in chaotic systems is a significant challenge. Our primary goal is to introduce a novel method for quantifying the inherent complexity of these signals, similar to resolution functions used in standard data analysis. A key aspect of our approach is to assign zero complexity to systems that exhibit either extreme regularity or extreme chaos. We designed machine learning networks specifically tailored to uncover hidden patterns within these noisy observables. This approach aims to enhance our ability to extract critical information from a wide range of applications, from classical noise to the complex quantum systems that produce noisy, intricate data sets.

Q 63.56 Thu 17:00 Tent

Efficient quantum control by composite ultrastrong field — •Kremena Parashkevova and Nikolay Vitanov — Center for Quantum Technologies, Faculty of Physics, Sofia University, James Bourchier 5 blvd., 1164 Sofia, Bulgaria

We present a study on coherent quantum control of a qubit by an ultrastrong driving field in the regime where the rotating-wave approximation cannot be applied. The resulting counter-rotating term makes traditional quantum control methods, such as resonant, adiabatic and shortcut techniques, unable to achieve high control accuracy. We identify the recently developed universal composite pulses as the only quantum control method which successfully maintains very high accuracy even in this ultrastrong coupling regime.

Q 63.57 Thu 17:00 Tent

Towards Scalable Quantum Computing with Trapped Ions: Single-Ion Addressing and Efficient Cooling — •Robin Strohmaier, Daniel Wessel, Alexander Müller, Jonas Vogel, Björn Lekitsch, and Ferdinand Schmidt-Kaler — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz

Trapped ions are a leading platform for scalable and fault-tolerant quantum computing. In this work, we present two critical advancements toward realizing scalable quantum computing with linear crystals of ions: precise single-ion addressing and efficient near-ground-state cooling of ion crystals.

Single ion addressing of the spin qubit in $^{40}Ca^{+}$ is achieved using a crossed acousto-optic deflector (AOD) setup. This system utilizes a tightly focused 400 nm laser beam to drive stimulated Raman transitions between spin states. We demonstrate a beam focus of 1 μm, enabling low crosstalk between neighboring ions. Additionally, we implement several ground state cooling schemes which can be used within sequences as well. This enables longer gate sequences and hence deeper algorithms. Combined with our new developed, SLE fabricated, glass trap and its low heating rates, these advancements support the handling of ion crystals with tens of ions, paving the way for operations involving multiple logical qubits. These results mark significant progress toward scalable quantum computation with trapped ions.

Q 63.58 Thu 17:00 Tent

Noisy Rydberg Quantum Gates — •Santiago Higuera Quintero[1], Sebastian Weber[1], Katharina Brechtelsbauer[1], Nicolai Lang[1], Tilman Pfau[2], Florian Meinert[2], and Hans Peter Büchler[1] — [1]Institute for Theoretical Physics III and IQST, University of Stuttgart, 70550 Stuttgart, Germany — [2]Institute of Physics and IQST, University of Stuttgart, 70550 Stuttgart, Germany

Modelling noise processes in noisy intermediate-scale quantum (NISQ) devices plays an important role in designing hardware and algorithms in the journey for scalable quantum computers. In this era, classical emulators of quantum systems can help to better understand typical errors in quantum information processing which arise from coupling to the environment and experimental limitations. We present a noise analysis of our gate protocols and determine relevant Kraus maps under typical noise sources to Rydberg-based platforms, such as: photon recoil, laser and thermal noise. Finally, we provide an overview of our online platform that provides users the opportunity to try out our gate-based emulator of the Rydberg quantum computer of the QRydDemo project and get familiar with its native gate operations.

Q 63.59 Thu 17:00 Tent

Quantum systems driven by nonclassical light treated using the hierarchy of pure states — •Vladislav Sukharnikov[1], Stasis Chuchurka[1], and Frank Schlawin[2] — [1]Department of Physics, Universität Hamburg, 22761 Hamburg, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, 22761 Hamburg, Germany

Quantum systems driven by nonclassical light fields have garnered significant attention, particularly in light of recent breakthroughs in high-harmonic generation using nonclassical light sources. Developing a comprehensive theoretical framework for these systems would be highly beneficial. However, the inherent complexity of the problem limits a fully general treatment. In this work, we investigate the interaction between an atomic system and nonclassical light, such as squeezed light, examining the dynamic evolution of both the atomic system and the field. To tackle this challenging problem, we employ a hierarchy of pure states to model the coupling to the field, which is treated as a non-Markovian bath. This method allows for parallelization and effectively treats multimode structure of the field, providing deeper insights into the underlying dynamics and expanding our understanding of these complex systems.

Q 63.60 Thu 17:00 Tent

Exploring Long-Range Interactions in Quantum Many-Body Systems — •Antonia Duft, Patrick Adelhardt, and Kai Phillip Schmidt — Friedrich-Alexander Universität Erlangen-Nürnberg

Long-range interactions play a crucial role in many quantum many-body systems and might influence their dynamics, critical behavior, and phases of matter. Experimentally, algebraically decaying long-range interactions $\sim r^{-(d+\sigma)}$ are relevant in various quantum-optical platforms, including ultracold atoms, trapped ions, and Rydberg atom arrays which can also serve as analogue quantum simulators. However, their theoretical treatment poses challenges compared to short-ranged systems. To address these, we utilize the method of perturbative Continuous Unitary Transformations (pCUT)combined with classical Monte Carlo (MC) techniques. A linked-cluster expansion is set up for long-range interactions using white graphs and the embedding is handled in a MC algorithm. This approach enables the extraction of high-order series expansions of physical quantities in the thermodynamic limit. The pCUT+MC approach can be employed to tackle a multitude of systems, including paradigmatic models like the spin-1/2 transverse field Ising model, XY model, and Heisenberg model. We further apply the method to spin-1 Heisenberg systems.

Q 63.61 Thu 17:00 Tent

Is Localization a security threat in Quantum Machine Learning? — •Yannick Werner[1], Nikolaos Palaiodimopoulos[1,2], Omid Faizy[2,3], Nico Piatkowski[4], Paul Lukowicz[1,2], and Maximilian Kiefer-Emmanouilidis[1,2] — [1]DFKI Kaiserslautern — [2]RPTU Kaiserslautern-Landau — [3]Sorbonne Université, Paris — [4]Fraunhofer IAIS, Sankt Augustin

As Quantum Machine Learning (QML) becomes more developed and widely used in commercial applications, addressing its security risks is essential. We examine Quantum Neural Networks (QNNs) as disordered quantum systems to explore whether effects like Many-Body Localization (MBL) could impact QNN tasks such as classifying or generating data. It has been shown, that applying a simple cyclic permutation after embedding the data and before readout can recover complex classical data from the measurements of a single disorder realization [1]. This suggests that a trained QNN, which effectively represents such a single disorder realization, could be vulnerable to exposing sensitive data it is supposed to classify. For instance, an eavesdropper might recover sensitive input data from stolen measurement results, a risk that is non-existent with classical classifiers. To address this, we analyse shallow variational quantum circuits with nearest-neighbour interactions and strongly varying weights, where MBL dynamics are expected. We assess their vulnerability to data recovery and examine the balance between expressibility, trainability, and security risks in QNN designs.

[1]arXiv:2409.16180v1 (2024).

Q 63.62 Thu 17:00 Tent

Gradient magnetometry with atomic ensembles — •Iagoba Apellaniz[1], Iñigo Urizar-Lanz[1], Zóltan Zimborás[1,2,3], Philipp Hyllus[1], and Géza Tóth[1,3,4] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, P. O. Box 644, ES-48080 Bilbao, Spain — [2]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, DE-14195 Berlin, Germany — [3]Wigner Research Centre for Physics, Hungarian Academy of Sciences, P.O. Box 49, HU-1525 Budapest, Hungary — [4]IKERBASQUE, Basque Foundation for Science, ES-48013 Bilbao, Spain

We study gradient magnetometry with an ensemble of atoms with arbitrary spin. We calculate precision bounds for estimating the gradient of the magnetic field based on the quantum Fisher information. For quantum states that are invariant under homogeneous magnetic fields, we need to measure a single observable to estimate the gradient. On the other hand, for states that are sensitive to homogeneous fields, a simultaneous measurement is needed. We present a method to calculate precision bounds for gradient estimation with a chain of atoms or with two spatially separated atomic ensembles. We also consider a single atomic ensemble with an arbitrary density profile, where the atoms cannot be addressed individually, and which is a very relevant case for experiments. Our model can take into account even correlations between particle positions. While in most of the discussion we consider an ensemble of localized particles that are classical with respect to their spatial degree of freedom, we also discuss the case of gradient metrology with a single Bose-Einstein condensate.

Q 63.63 Thu 17:00 Tent

A Weak Measurement Based Toy Model to Probe Quantum Properties in a Cosmological Setting — •Joel Huber[1,2,3], Časlav Brukner[3], and Igor Pikovski[4] — [1]Universität Siegen — [2]ETH Zurich — [3]IQOQI Vienna — [4]Stevens Institute of Technology

Probing quantum properties in cosmology could offer profound insights into the fundamental nature of the universe. We present a novel perspective on the detectability of quantum properties in cosmology. Firstly, we motivate a set of fundamental limitations inherent to observational cosmology and translate them into operational constraints for a general quantum system. We then propose a toy model and show how the limitations can be successfully circumvented by studying weakly coupled pointer degrees of freedom. We find that the non-commutativity of observables can be inferred by comparing measurement statistics, even though limited by the weakness of the measurements. This result can provide a hint but not conclusive evidence, for the quantum nature of the system. Finally, we investigate generalised Leggett-Garg inequalities, which separate classical from non-classical temporal correlations. We demonstrate that they cannot be violated using three consecutive weak measurements while remaining agnostic about the underlying interactions.

Q 63.64 Thu 17:00 Tent

Towards a quantum processor with non-local interactions and programmable connectivity. — •Franz von Silva-Tarouca[1], Stephan Roschinski[1], Johannes Schabbauer[1], and Julian Léonard[1,2] — [1]TU Wien, Atominstitut, Vienna Center for Quantum Science and Technology (VCQ), Austria — [2]Institute of Science and Technology Austria (ISTA), Am Campus 1, 3400 Klosterneuburg, Austria

Quantum computers and simulators are especially promising for tackling problems that require a high degree of entanglement. However, the efficient and deterministic generation of many-body entanglement still poses a challenge.

We report on progress towards building a quantum processor based on an array of single atoms trapped in optical tweezers and strongly coupled to a high-finesse fiber cavity. The cavity enables non-local interactions, mediated by the joint coupling of the atoms to the cavity mode. Microscopic addressing via the optical tweezers allows for tuning this coupling for each atom, enabling programmable connectivity. This, combined with other established techniques in cavity quantum information processing, provides us with an extensive experimental toolkit for generating many-body entanglement and a variety of quantum computation and simulation experiments.

Q 63.65 Thu 17:00 Tent

Quantum simulator with 40 nuclear spins in diamond — •Christina Ioannou — Qutech, TuDelft, Netherlands

Individually controllable ^{13}C nuclear spins in diamond, associated with a single NV-center, can be used to realise a quantum simulator for the observation of many-body quantum phenomena. On this poster I will discuss the capabilities of the platform such as collective initialisation with dynamic nuclear polarisation, individual spin control and readout as well as global pulses, which make up a comprehensive toolbox for studying many-body phenomena under a range of tunable Floquet Hamiltionians. Applications of this quantum simulator include observing novel phases of matter such as discrete time crystals, studying the thermalisation a many-body 3D-coupled spin system under Floquet driving, Hamiltonian engineering and estimating entanglement entropies with randomised measurements.

Q 63.66 Thu 17:00 Tent

Quantum strategies for rendezvous and domination tasks on graphs with mobile agents — •Giuseppe Viola[1] and Piotr Mironowicz[2,3,4] — [1]University of Siegen, Siegen, Germay — [2]University of Gdansk, Gdansk, Poland — [3]Stockholm University, Stockholm, Sweden — [4]Gdansk University of Technology, Gdansk, Poland

This work explores the application of quantum non-locality, a renowned and unique phenomenon acknowledged as a valuable resource. Focusing on a novel application, we demonstrate its quantum advantage for mobile agents engaged in specific distributed tasks without communication. The research addresses the significant challenge of rendezvous on graphs and introduces a new distributed task for mobile agents grounded in the graph domination problem. Through an investigation across various graph scenarios, we showcase the quantum advantage. Additionally, we scrutinize deterministic strategies, highlighting their comparatively lower efficiency compared to quantum strategies. The work concludes with a numerical analysis, providing further insights into our findings.

Q 63.67 Thu 17:00 Tent

Optimal control of arbitrary perfectly entangling gates for open quantum systems — •Adrian Romer, Daniel Reich, and Christiane P. Koch — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Berlin, Germany

Perfectly entangling gates (PE) are crucial for various applications in quantum information. One method to realize these gates is with the help of an external control field, whose concrete shape is found using optimal control theory. Instead of optimizing the shape that realizes a specific gate, the optimization target can be extended to the full set of PE. This increases the flexibility of optimization and allows to find the best PE from the set of all PE. First, we show that it is possible to construct the unitary part of an unknown coherent evolution by propagating specifically talilored density matrices. We then extend this construction method to approximate the unitary part of a non-unitary evolution. Lastly, we employ this method to superconducting qubits, where we numerically find optimized control fields that generate maximally entangled states for a desired gate duration, even if dissipation is present in the system.

Q 63.68 Thu 17:00 Tent

Phase Space Dynamics of Continuous-Variable, Open Bosonic Systems with Generative Neural Quantum States — •Ege Görgün — Institut für Festkörpertheorie und Optik, Jena, Deutschland

Simulating the dynamics of interacting many-body quantum systems poses a significant challenge due to the exponential complexity scaling with system size. In this work, we derive the quantum master equation for phase space quasi-probability distributions across a diverse set of open bosonic systems, providing an analytical foundation for tracking their dynamics. We then present a neural quantum state (NQS) ansatz based on an invertible neural network (INN) trained within a time-dependent variational principle (TDVP) framework, offering a versatile approach for modelling the phase space dynamics of a broad class of continuous-variable systems. Leveraging the inherent invertibility of INNs, our model provides a robust architecture that can serve not only as a Monte Carlo sampler but also enable direct access to probability distributions over time through latent space dynamics.

Q 63.69 Thu 17:00 Tent

Correlations in non Markovian Open Quantum System Dynamics — •Isabelle McEntee, Adrian Romer, and Christiane P. Koch — Freie Universität Berlin, Berlin, Germany

Open quantum systems are complex and not easily described. To simulate these dynamics with an equation of motion, we must make many assumptions, in particular weak system bath coupling and Markovianity. This work focuses on two methods that do not make these assumptions and allow for the simulation of correlations that occur in non Markovian dynamics. The first is called the Surrogate Hamiltonian method (Baer & Kosloff, 1997, The Journal of Chemical Physics), here the number of bath modes that interact with our system is limited to create a smaller, finite surrogate bath. This method treats correlations through different configurations of bath excitations. The second method (Chin et al., 2010, Journal of Mathematical Physics), involves mapping system and bath onto a semi-infinite chain which is evaluated using the Density Matrix Renormalization Group (DMRG) technique. This technique allows for correlations to be treated through tensor decomposition. Both methods truncate the bath and thus the system-bath correlations. We study and compare how correlations are built in these two approaches.