Q 8: QI Poster I (joint session QI/Q)

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

Q 8.1 Mon 16:30 Empore Lichthof

Towards multi-photon tests of hyper-complex quantum mechanics — •Ece Ipek Saruhan, Marc-Oliver Pleinert, and Joachim von Zanthier — Quantum Optics and Quantum Information, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 1, 91058 Erlangen, Germany

Axioms of quantum mechanics do not tell much about the structure of the Hilbert space such as, e.g., the number system, which could be real, complex, or hyper-complex. Probabilities are amplitude squares of wave functions, which are defined on a complex space in general. Can one consider the result of a dot product to be a hyper-complex number? Asher Peres proposed a way to test hyper-complex quantum mechanics with a single particle scattered from 3 different scatterers [1]. We adapt this test to a 3-slit interference setup and extend it to multi-slit and multi-particle scenarios. We construct Peres-like functions to see if the multitude of paths and particles show different sensitivity to, still hypothetical, hyper-complex phases.

[1] A. Peres, Phys. Rev. Lett. 42, 683 (1979).

Q 8.2 Mon 16:30 Empore Lichthof

An analysis on the almost quantum correlation set — •Vitor Sena and Rafael Rabelo — University of Campinas, Brazil

A good way to investigate the foundations of quantum theory is through the correlations it allows between results of measurements performed on spatially separated systems. These correlations may present some known nonclassical phenomena such as Bell nonlocality, but, interestingly, the set of nonlocal correlations allowed by quantum theory is quite specific and, in some sense, limited. There is a set of correlations slightly larger than this, known as the almost quantum correlations set, which presents similarities and differences with the set of quantum correlations. In this work, we study the relationship between these sets by numerically estimating their relative volumes in different scenarios. In doing so, we seek to understand the kind of correlations allowed by each one and how their differences can be shown quantitatively.

Q 8.3 Mon 16:30 Empore Lichthof

Reducing Bias in Quantum State Tomography — •Yien Liang[1,2] and Matthias Kleinmann[1] — [1]Universität Siegen, Walter-Flex-Straße 3, D-57068 Siegen, Germany — [2]Peking University, Beijing 100871, China

Quantum state tomography aims to estimate the quantum state of a system using quantum measurements. It is well known that such an estimate cannot be perfect, that is, the procedure may yield an operator with negative eigenvalues or the mean reconstructed state deviates from true state. This is the dilemma of having a nonphysical reconstruction or a biased estimator. It also has been shown that any unbiased estimator has to yield rather large negative eigenvalues. We ask the complementary question: What is the minimum bias of an estimator, even if one is willing to accept an increased variance of the estimator? We show that the bias can indeed be improved by orders of magnitude, but at the price of being rather pathological. We furthermore discuss the behavior of estimators with low bias compared to canonical estimators for large sample sizes and many qubits.

Q 8.4 Mon 16:30 Empore Lichthof

Witnessing non-Markovianity in quantum Brownian motion by quasi-probability distributions in phase-space — •Irene Ada Picatoste Fernández[1], Moritz Ferdinand Richter[1], and Heinz-Peter Breuer[1,2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, University of Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

The theory of open quantum systems aims to describe the dynamics of a quantum system coupled to an environment using a limited number of degrees of freedom. The Caldeira-Leggett model of quantum Brownian motion represents a physically interesting example of such systems showing strong memory effects, i.e., non-Markovian dynamics, in certain parameter regimes. Recently, a witness for non-Markovianity has been developed which is based on the Kolmogorov distance between quasi-probability distributions of two states [1]. Additionally, for Gaussian dynamics, a new measure of non-Markovianity can be defined using exclusively the Glauber-Sudarshan P-function. Here, we apply this witness to the Caldeira-Leggett model and show the behaviour of the non-Markovianity measure in different scenarios, while studying where the witness works best.

[1] M. F. Richter, R. Wiedenmann and H.-P. Breuer, arXiv:2210.06058 [quant-ph].

Q 8.5 Mon 16:30 Empore Lichthof

Photon-number resolved model for multimode quantum optical setups based on Gaussian states — •Florian Niederschuh, Erik Fitzke, and Thomas Walther — Institute for Applied Physics, TU Darmstadt, Darmstadt, Germany

Experiments in quantum optics and photonic quantum information protocols regularly employ multimode states with low photon numbers. While early setups used single photon avalanche diodes, recent advances aim at the realization of photon-number resolving detectors. Consequently, mathematical models for the prediction of photon-number resolved detection probabilities may provide valuable insight and aid in experimental design. Here, a formalism for simulating the photon statistics of Gaussian states is presented. It is based on the construction of suitable generating functions, which are further processed by software for automatic differentiation. This allows the extraction of various statistical quantities, e.g. the photon number distribution, cumulative probabilities and statistical moments. The model considers an array of experimental imperfections and agrees with recent measurement results of an entanglement-based phase-time coding setup for quantum key distribution [Fitzke et al. (2022). PRX Quantum, 3, 020341].

Q 8.6 Mon 16:30 Empore Lichthof

Entanglement classification schemes : comparison between Majorana representation and algebraic geometry approaches — •Tom Weelen[1], Naïm Zénaïdi[2], Pierre Mathonet[2], and Thierry Bastin[1] — [1]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, BE-4000 Liège, Belgium — [2]Département de Mathématique, Université de Liège, BE-4000 Liège, Belgium

Quantum entanglement can be of different kinds [1] and classifying the quantum states in this respect may represent a difficult challenge in general multipartite systems. In particular, entanglement classes that are inequivalent under stochastic local operations and classical communication (SLOCC) are of fundamental importance. For N-qubit systems with $N > 3$, there is an infinity of such SLOCC entanglement classes [1] and it makes sense to gather them into a finite number of families, as was done for symmetric states in Refs. [2,3] using two distinct approaches (Majorana representation and algebraic geometry tools, respectively). Here, we compare these two structures and identify whether they can be embedded into one another or not. To do so, we formulate the structure of Ref. [2] in terms of k-secants and k-tangents (k a positive integer) of the Veronese variety [3] and we prove that only the k-tangent structuration provides a coherent structure compatible with that of Ref. [3].

[1] W. Dür et al., Phys. Rev. A **62**, 062314 (2000). [2] T. Bastin et al., Phys. Rev. Lett. **103**, 070503 (2009). [3] M. Sanz et al., J. Phys. A: Math. Theor. **50**, 195303 (2017).

Q 8.7 Mon 16:30 Empore Lichthof

What channels can be implemented without a reference frame? — •Fynn Otto — University of Siegen, Germany

Quantum reference frames are needed for communication tasks for which the method of information encoding matters. In contrast to – for example – sending integers, reference frames are needed for communicating, e.g. quantum phases or directional information. Even if a classical communication link between two parties is established, it is not possible to send a *direction in space*.

Lacking a reference frame limits the set of operations that can be performed deterministically. Changing reference frames is equivalent to the passive evolution of a state under the unitary operator $U(g)$, representing the transformation g. The transformations between reference frames form a group G, and allowed frame-agnostic channels turn out to be G-covariant: the channel $\mathcal{E}$ must commute with every $U(g)$.

Here we investigate the reachable states for two important cases: lacking a phase reference (corresponding to the group $G = U(1)$) and lacking a Cartesian frame alignment ($G = SU(2)$). Examples of G-covariant state transformation are provided along with possible classification and interpretation of the reachability structure.

Q 8.8 Mon 16:30 Empore Lichthof

Leveraging noisy physical observables with machine learning. — •Adisorn Panasawatwong, Ulf Saalman, and Jan-Michael Rost — Max-Planck-Institute for the Physics of Complex Systems

A noisy light pulse containing many frequencies leads to deterministic electron dynamics in the illuminated target, whose response will also look noisy. At first glance, it cannot be distinguished from a random signal which results from fully chaotic dynamics. While the latter contains little information, the former contains valuable information about the target system, even more than its (linear) response to a Fourier-limited single-frequency pulse.

We are developing a machine learning-based approach which can distinguish the two kinds of noisy signals according to their actual information content: their complexity. Without using entropy, we show emergence of information by interpreting the result from auto-encoder.

Knowing the degree of complexity in the signal enables us to develop networks tailored to extract the amount of information about the target which is contained in the noisy observable due to its complexity.

Q 8.9 Mon 16:30 Empore Lichthof

Entanglement in free fermion systems — Lexin Ding[1,2], •Gesa Dünnweber[1,2], and Christian Schilling[1,2] — [1]Faculty of Physics, Arnold Sommerfeld Centre for Theoretical Physics (ASC), Ludwig-Maximilians-Universität München, Theresienstr. 37, 80333 Munich, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 Munich, Germany

Entanglement is becoming an increasingly important resource for the realisation of quantum information tasks. Several measures of mode entanglement have been proposed for fermionic systems.

We consider a spinful free fermion chain under nearest neighbour hopping and determine an analytic measure of the resulting site-site entanglement. Including in particular the restrictions imposed by parity or particle number superselection rules, we study how various factors affect the accessible entanglement. This approach is extended to a model that includes an additional hopping term where we investigate the evolution of entanglement across a Lifshitz-type transition. Relating orbital entanglement to the concept of locality within a molecule, we present numerical results for a hydrogen chain.

Finally, we are interested in protocols for extracting entanglement from fermionic systems such as entanglement swapping, where superselection rules demand modifications to the established protocols for qubits.

Q 8.10 Mon 16:30 Empore Lichthof

Quantum Key Distribution from Bound Entanglement — •Zeynab Tavakoli[1] and Gláucia Murta[2] — [1]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany — [2]Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

Quantum key distribution (QKD) aims to secure communication and establish a secret key between two honest parties. A secret key is a string of independent and random bits known to both parties. Key distillation in QKD is related to entanglement distillation; by distilling a maximally entangled state, one can get the key by measuring it. The belief was that achieving security is equivalent to distilling maximally entangled states. However, Authors of [Phys.Rev.Lett.80,5239,(2005)] show bound entangled states are usable to obtain key. Bound entangled states are quantum states that no maximally entangled states can be distilled from them using LOCC. Bound entangled states used in QKD have entanglement, which protects correlations from the environment. However, the entanglement is so twisted that it cannot be brought into a maximally entangled state. In this work, we studied known examples of bound entangled states useful for QKD. In particular, we investigate the noise tolerance of the corresponding QKD protocol, construct new bound entangled states around the original examples, and investigate their achievable key rates. Finally, we investigate if bound entangled states can be used in a simple QKD protocol where a single copy of the state is distributed and measured each round.

Q 8.11 Mon 16:30 Empore Lichthof

Randomness Certification for Multipartite Arbitrary Dimensional Systems — Yu Xiang[1,2], •Yi Li[1], and Qiongyi He[1,2,3] — [1]State Key Laboratory for Mesoscopic Physics, School of Physics, Frontiers Science Center for Nano-optoelectronics, and Collaborative Innovation Center of Quantum Matter, Peking University, Beijing 100871, China — [2]Collaborative Innovation Center of Extreme Optics, Shanxi University, Taiyuan, Shanxi 030006, China — [3]Peking University Yangtze Delta Institute of Optoelectronics, Nantong, Jiangsu 226010, China

We first present a method to certify the randomness generated in multipartite arbitrary dimensional systems, closely to the actual situation where some of the untrusted sides are measured locally. The proposed method also provides a hierarchy of upper and lower bounds of randomness with different assumptions. Comparing with the bipartite scenario, our result shows more randomness can be certified in this asymmetric network. Surprisingly, for some systems, we find that there exists nonzero certified randomness on the untrusted parties together, even though no randomness can be induced in either mode individually, which implies randomness in the multipartite network can be used for some security tasks in the future. The ease of our method is also demonstrated by adopting some existing experimental data. Finally, we prove that multipartite steering is necessary for generating randomness in the asymmetric network.

Q 8.12 Mon 16:30 Empore Lichthof

Markovian master equations beyond the adiabatic and inertial limit — •Josias Langbehn[1], Roie Dann[2], Raphael Menu[3], Giovanna Morigi[3], Ronnie Kosloff[2], and Christiane Koch[1] — [1]Freie Universität Berlin, Berlin — [2]Institute of Chemistry, Hebrew University, Jerusalem — [3]Universität des Saarlandes, Saarbrücken

Markovian master equations in Gorini-Kossakowski-Sudarshan-Lindblad (GKLS) form can accurately describe the dynamics of many open quantum systems ranging from optical to solid state systems. Adding a drive to the system complicates the derivation of any such master equation. The Markovian framework has been extended to drives in the adiabatic regime [1] and beyond that to inertial drives within the "non-adiabatic master equation" (NAME) [2]. The aim of this work is to extend this framework to drives that go even beyond the inertial limit by introducing a numerical scheme for finding an eigenoperator basis. In principle this allows for arbitrary drives, going as far as Markovian master equations in GKLS form remain valid. Moreover, the numerical scheme allows treating situations where no inertial solution can be found analytically. This opens the door for optimal control tasks where the time-dependency of the optimal drives may not be adiabatic/ inertial. We observe significant deviations between the NAME and the adiabatic/ inertial limit in multiple exemplary systems considered.

[1] Albash, T., Boixo, S., Lidar, D. A. & Zanardi, P. New J. Phys. 14, 123016 (2012). [2] Dann, R., Levy, A. & Kosloff, R. Phys. Rev. A 98, 052129 (2018).

Q 8.13 Mon 16:30 Empore Lichthof

Mimicking non-Markovian dynamics using the stochastic surrogate Hamiltonian — •Jonas Fischer and Christiane Koch — Freie Universität Berlin

Some control tasks, like qubit reset, demand interaction between the system and environment. In order to perform these tasks quickly, it is beneficial if this coupling is as strong as possible. Typically, this leads to non-Markovian dynamics, for which there is no unified propagation method so far.

One possible candidate is the surrogate Hamiltonian. The real environment is substituted by a collection of two-level systems that capture the influence of the real environment on the system. This allows for the propagation of the full Hilbert space, allowing for the description of non-Markovian dynamics.

Due to the truncation of the Hilbert-space, this method is limited to short timescales. At a certain point in time, the environmental modes will saturate and recurrences in the system dynamics will occur. The stochastic surrogate Hamiltonian is aiming to resolve this issue by randomly resetting the environmental modes into a thermal state. These resets should be performed in such a way that the recurrences get suppressed, but at the same time, they should destroy as few correlations as possible. We present a reset method that reproduces the correct reduced density matrices for both the reset mode and the other environmental modes.

Q 8.14 Mon 16:30 Empore Lichthof

Quantum transport in noisy networks of coupled harmonic oscillators — •Emma King, Raphael Menu, and Giovanna Morigi — Theoretische Physik, Universitat des Saarlandes, D-66123 Saarbruecken, Germany

In recent years rapid progress has been made towards the realisation of scalable quantum computers. While devices with an increasing number of qubits are being realised, the present size does not yet allow for the efficient implementation of error-correction schemes. This highlights the importance of understanding the role of an environment on the target quantum coherent dynamics. In this work we address the question as to which properties of an external environment are detrimental, and, in contrast, which properties can be used as resources for quantum transport. For this purpose we consider two chains of coupled harmonic oscillators with long range interactions that decay in a power law fashion. The one chain acts as the system while the other is the environment. In this setting we derive a quantum master equation starting from the Liouville-von Neumann equation and identify the requirements on the environment for which the master equation has the Lindblad form. We then analyse transport in the chain as a function of the environment characteristics, identifying the regime(s) in which it leads to faster propagation of information along the chain.

Q 8.15 Mon 16:30 Empore Lichthof

Engineering a heat engine purely driven by quantum coherence — •Stefan Aimet — Imperial College London, London, United Kingdom — FU Berlin, Berlin, Germany

The question of whether quantum coherence is a resource beneficial or detrimental to the performance of quantum heat engines has been thoroughly studied but remains undecided. To isolate the contribution of coherence, we analyse the performance of a purely coherence-driven quantum heat engine, a device that does not include any heat flow during the thermodynamic cycle. The engine is powered by the coherence of a multi-qubit system, where each qubit is charged via interaction with a coherence bath using the Jaynes-Cummings model. We demonstrate that optimal coherence charging and hence extractable work is achieved when the coherence bath has an intermediate degree of coherence. In our model, the exctractable work is maximised when four copies of the charged qubits are used. Meanwhile, the efficiency of the engine, given by the extractable work per input coherence flow, is optimised by avoiding coherence being stored in the system-bath correlations that is inaccessible to work. We numerically find that the highest efficiency is obtained for slightly lower temperatures and weaker system-bath coupling than those for optimal coherence charging.

Q 8.16 Mon 16:30 Empore Lichthof

Design of a 4-party active base choice phase-coding quantum key distribution multi-user hub — •Adrian Klute, Maximilian Tippmann, Lucas Bialowons, Erik Fitzke, and Thomas Walther — TU Darmstadt, Institute of Applied Physics, 64289 Darmstadt

In the developing field of secure quantum communication, several quantum key distribution (QKD) systems have been tested with various protocols. However, building scalable QKD systems with more than 2 parties is a challenging task. We recently presented a 4-party star-shaped quantum hub system, which is based on time-bin entanglement. The crucial part in this setup is the precise building of interferometers. Precise building methods with sufficient reliability are needed to exchange keys with low quantum bit error rate between all user pairs of the hub. Not only the building method but also a suitable design choice of the interferometer can reduce uncertainties in the building process. In that sense we are discussing the technological challenges of two known interferometer designs for an active phase-coding protocol, a Sagnac-Michelson and a Sagnac-Mach-Zehnder configuration. We present first results to assess the success of the building method that we used.

Q 8.17 Mon 16:30 Empore Lichthof

Towards a city-wide quantum key distribution network with a multi-user phase-time coding quantum key hub — •Maximilian Tippmann, Erik Fitzke, Till Dolejsky, Florian Niederschuh, and Thomas Walther — TU Darmstadt, Institute of Applied Physics, 64289 Darmstadt

Quantum key distribution (QKD) paves a way to make today's IT-infrastructure resilient against future attacks e.g. from quantum computers. Various QKD protocols and setups have been tested over the last decades. However, most experiments focus on two-user systems, thus not allowing an easy scaling to multiple users. Here, we report on a quantum key hub implementing the phase-time protocol with a central untrusted node for simultaneous pairwise key exchange, tested with four users, but readily scalable to more than 100 users. The central untrusted node consists of an entangled photon pair source, and provides high-flexibility, allowing plug-and-play reconfiguration of the connected parties. Furthermore, the setup has been tested with real-world deployed fiber demonstrating the practicability of our approach. Going towards a city-wide deployment, we look into setup specific issues, including post-processing and alignment of the setup, arising from the distribution of the communicating parties to a city-wide scale.

Q 8.18 Mon 16:30 Empore Lichthof

System Components for Single-Photon Quantum Key Distribution in the Telecom C-band — •Timm Gao, Mareike Lach, and Tobias Heindel — Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

We report on the evaluation of system components for single-photon based quantum communication in the telecom C-band. We evaluate the performance of different hardware components for quantum key distribution. Special emphasis lies here on the receiver module, where free-space and fiber-based approaches are comparatively discussed.

Q 8.19 Mon 16:30 Empore Lichthof

Night Sky Background Measurement for Quantum Key Distribution — •Rengaraj Govindaraj[1,2], Michael Auer[1,2,3], Adomas Baliuka[1,2], Peter Freiwang[1,2], Lukas knips[1,2,4], and Harald Weinfurter[1,2,4] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799, München, Germany — [2]Munich Center for Quantum Science and Technology, 80799, München, Germany — [3]Universität der Bundeswehr, 85577 Neubiberg, Germany — [4]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

Free-space satellite-to-ground quantum key distribution (QKD) enables two authenticated parties - potentially separated by global distances - to exchange a secret key that can be used for symmetric cryptography. However, the performance of free-space QKD crucially depends on the quantum bit error ratio (QBER) and hence on the contributions of background light sources such as light from natural sources as the sun or stars as well as from artificial light sources. As those noise contributions vary with time of day, season, weather and location, their study is important for estimating future QKD missions. We here present our experimental method to map the night sky background in terms of its brightness in the spectral bands around 850nm and 1550nm and discuss the implications for satellite-based QKD.

Q 8.20 Mon 16:30 Empore Lichthof

Designing versatile and performant DM-CV QKD systems for the QuNET initiative — •Stefan Richter[1,2], Ömer Bayraktar[1,2], Kevin Jaksch[1,2], Bastian Hacker[1,2], Imran Khan[1,2,5], Emanuel Eichhammer[1,5], Emmeran Sollner[1,5], Twesh Upadhyaya[3], Jie Lin[3], Norbert Lütkenhaus[3], Florian Kanitschar[4], Stefan Petscharnig[4], Thomas Grafenauer[4], Ömer Bernhard[4], Christoph Pacher[4], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Chair of Optical Quantum Technologies, Department of Physics, Friedrich Alexander University Erlangen-Nuremberg, Erlangen, Germany — [2]Quantum Information Processing Group, MPI for the Science of Light, Erlangen, Germany — [3]Institute for Quantum Computing, Dept. of Physics and Astronomy, University of Waterloo, Canada — [4]Security & Communication Technologies Unit, Austrian Institute of Technology, Vienna, Austria — [5]now with KEEQuant GmbH, Fürth, Germany

Continuous-variable quantum key distribution (CV-QKD) is a key technology for guarding critical communication links against the rapidly growing threat of large-scale quantum computers. We present our progress in implementing a versatile and performant CV-QKD system designed for metropolitan fiber optical networks. Important performance indicators estimated during a public technology demonstration in August 2021 and recent improvements will be discussed. We also highlight special design aspects and challenges of the implementation, in particular with regard to stability and error correction requirements.

Q 8.21 Mon 16:30 Empore Lichthof

Night Sky Background Measurement for Quantum Key Distribution — •Rengaraj Govindaraj[1,2], Michael Auer[1,2,3], Adomas Baliuka[1,2], Peter Freiwang[1,2], Lukas Knips[1,2,4], and Har-

ald Weinfurter[1,2,4] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799, München, Germany — [2]Munich Center for Quantum Science and Technology, 80799, München, Germany — [3]Universität der Bundeswehr, 85577 Neubiberg, Germany — [4]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

Free-space satellite-to-ground quantum key distribution (QKD) enables two authenticated parties - potentially separated by global distances - to exchange a secret key that can be used for symmetric cryptography. However, the performance of free-space QKD crucially depends on the quantum bit error ratio (QBER) and hence on the contributions of background light sources such as sun or stars as well as artificial light sources. As those noise contributions vary with time of day, season, weather and location, their study is important for planning the location and performance of ground station's future QKD missions. We here present our experimental method and device to map the night sky background in terms of its brightness in the spectral bands around 850nm and 1550nm and discuss the implications for satellite-based QKD.

Q 8.22 Mon 16:30 Empore Lichthof

Towards quantum communication over intercity optical fiber link — •Ali Hreibi, Ann-Kathrin Kniggendorf, Harald Schnatz, and Stefan Kück — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

We report on the status of the PTB's work to establish a quantum communication test bed between Braunschweig and Hanover (the "Niedersachsen Quantum Link"). In this context, we present an overview of the quantum key distribution (QKD) system based on the BBM92 protocol set up at PTB and the test of quantum communication via optical fiber up to 90 km in length. The QKD system generates Polarization-entangled photon pairs using the nonlinear optical process of spontaneous parametric down-conversion, and transmits the entangled photon pairs (signal, and idler) to a local and a remote location through the optical fiber. Photons are detected on both sides and measurement data is processed by the system in order to generate a secure quantum encryption key. The Communications security relies on the laws of quantum mechanics and the non-cloning theorem which prevents a quantum state from being copied or measured without disturbing it.

Q 8.23 Mon 16:30 Empore Lichthof

The Ideal Wavelength for Daylight Free-Space Quantum Key Distribution — •Mostafa Abasifard[1], Chanaprom Cholsuk[1], Roberto G. Pousa[2], Anand Kumar[1], Ashkan Zand[1], Daniel K. L. Oi[2], and Tobias Vogl[1,3] — [1]Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, 07745 Jena, Germany — [2]Computational Nonlinear and Quantum Optics, SUPA Department of Physics, University of Strathclyde, Glasgow G4 0NG, United Kingdom — [3]Fraunhofer-Institute for Applied Optics and Precision Engineering IOF, 07745 Jena, Germany

Quantum key distribution (QKD) has matured from proof-of-principle demonstrations in the lab to commercial systems. Intercontinental quantum communication distances have been bridged with satellites. Satellite-based quantum links can only operate during the night, as the sunlight would otherwise saturate the detectors used to measure the quantum states. For high data rates and continuous availability, operation during daylight is desirable.

We model a satellite-to-ground quantum channel for the BB84 protocol in order to determine the optimal wavelength for daytime free-space QKD. We look at the 400 nm to 1700 nm wavelength range and find extractable secret bits per signal for several light sources. As expected, the Fraunhofer lines appear as peaks in the spectrum of the secure data rate. For the ideal wavelength, we also propose a true single photon source, based on a resonator coupled color center in hexagonal boron nitride.

Q 8.24 Mon 16:30 Empore Lichthof

Dynamic Polarization State Preparation for Single-Photon Quantum Cryptography — •Koray Kaymazlar, Tim Gao, Daniel Vajner, Lucas Rickert, and Tobias Heindel — Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

Quantum key distribution (QKD) systems using polarization encoding require fast modulation of the polarization states of single-photon pulses. Here, we present a setup for preparing the polarization of single photons dynamically. The system consists of electronics based on a field programmable gate array (FPGA) and a digital to analog converter (DAC) driving a free space electro optic modulator (EOM) with 500 MHz bandwidth. We characterize and optimize the performance of this setup in terms of extinction ratio and repetition rate and discuss its suitability for applications in QKD experiments.

Q 8.25 Mon 16:30 Empore Lichthof

Investigation of the phase-space distribution of the BPSK-encoded optical coherent signal from a geostationary satellite — •Hüseyin Vural[1], Conrad Rössler[1], Andrew Reeves[2], Bastian Hacker[1], Thomas Dirmeier[1], Karen Saucke[3], and Christoph Marquardt[1] — [1]Max-Planck Institut für die Physik des Lichts (MPL) — [2]Deutsches Zentrum für Luft- und Raumfahrt (DLR) - Institut für Kommunikation und Navigation — [3]Tesat Spacecom

Coherent optical communication between a satellite and a terrestrial ground station can facilitate classical as well as quantum-limited communication. In a recent paper, we demonstrated quantum limited signals from a geostationary satellite in a homodyning measurement, that indicate the viability of long-distance quantum key distribution (QKD) and global secure communication. Here, we investigate the phase-space distribution of the BPSK-encoded coherent signal from the same satellite, however at an optical ground station in an urban area and by heterodyning the quantum signal with a free running commercial laser. Our results indicate that scalable solutions for quantum-limited signals may be in reach.

Q 8.26 Mon 16:30 Empore Lichthof

Single atoms in optical cavities as source for multiphoton graph states — •Leonardo Ruscio, Philip Thomas, Olivier Morin, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Generating multiphoton entangled states is an essential step for the development of quantum information protocols such as measurement based quantum computation. Thanks to their weakly interacting nature, entangled photons are in fact ideal qubit carriers. So far, the most successful source of entangled photons has been spontaneous parametric down conversion, where scaling up is dramatically limited by its intrinsically probabilistic nature. We experimentally demonstrate the feasibility of a single Rubidium atom in an optical cavity as an efficient source of multiphoton graph states [1]. We use the atom as a memory mediating the entanglement generation between the photons and we efficiently grow GHZ states of up to 14 photons and linear cluster states of up to 12 photons. With an overall efficiency of 43%, our experiment opens a way towards scalable measurement-based quantum computation and communication, where this scheme could be for example extended to two atoms in a cavity to generate higher-dimensional cluster states.

[1] P.Thomas et al., Nature 608, 677-681 (2022)

Q 8.27 Mon 16:30 Empore Lichthof

Driven Gaussian Quantum Walks — •Philip Held[1], Melanie Engelkemeier[1], Syamsundar De[1], Sonja Barkhofen[1], Jan Sperling[2], and Christine Silberhorn[1] — [1]Paderborn University, Integrated Quantum Optics, Institute of Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098, Paderborn, Germany — [2]Paderborn University, Theoretical Quantum Science, Institute of Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098, Paderborn, Germany

Quantum walks function as essential means to implement quantum simulators, allowing one to study complex and often directly inaccessible quantum processes in controllable systems. In this contribution, the new notion of a driven Gaussian quantum walk is presented. Here, instead of a unitary operation, a nonlinear map is used to describe the operation of the quantum walk in optical settings. Including nonlinear elements as core components, this type of quantum walk introduces quantumness of the dynamic itself, regardless of the input state. A parametric down-conversion is chosen as the nonlinear operation, introducing new walkers and squeezing during the evolution. To characterize nonlinear, quantum, and quantum-nonlinear effects following from this evolution, a full framework for driven Gaussian quantum walks is developed. In particular, the generation and amplification of highly multimode entanglement, squeezing, and other quantum effects are studied over the duration of the nonlinear walk.

Q 8.28 Mon 16:30 Empore Lichthof

Quantum Simulation of Biased Open System Dynamics —

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We present a protocol for the generation of rare quantum jump trajectories on a digital quantum simulator. Our approach allows to bias open system dynamics with regard to any, even non-linear, function, e.g. it can increase or decrease the likelihood of trajectories with specific emission patterns and correlation properties. We derive the dynamical map of the corresponding biased process. Moreover, we show how the biased open systems dynamics can be implemented on an IBM quantum processor. Using as an example an open two-level system we discuss challenges and current limitations of this approach.

Q 8.29 Mon 16:30 Empore Lichthof

Preparing ground states of the Fermi-Hubbard model with shallow quantum circuits — •Tobias Schmale[1], Bence Temesi[1], Hamed Saberi[1], and Hendrik Weimer[2,1] — [1]Institut für Theoretische Physik, Hannover, Germany — [2]Institut für Theoretische Physik, TU Berlin, Germany

The 2D Fermi-Hubbard model is a paradigmatic model in condensed matter physics, potentially holding the key to understanding high-temperature superconductivity. We turn to digital quantum simulations of the model, as classical simulation methods remain prohibitively challenging. We investigate a strategy for adiabatic preparation of the ground state by shallow quantum circuits running in constant time on a highly parallelized architecture. Additionally, we consider a simplified architecture consisting of a single computing register in a trapped-ion architecture based on ion shuttling, where we find that a single auxiliary qubit is sufficient to implement the mapping from fermions to qubits. We show that these architectures naturally allow for the realization of extensions to the Hubbard model such as next-nearest-neighbor hopping, which might be crucial to stabilize d-wave superconductivity.

Q 8.30 Mon 16:30 Empore Lichthof

Quantum Simulations: Endeavours with trapped ions in a 2D array and a Linear Paul trap — •Apurba Das, Deviprasath Palani, Florian Hasse, Maharshi Pran Bora, Lucas Eisenhart, Tobias Spanke, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Freiburg, Deutschland

Individual ions, trapped in a customised trap architecture offer one of the most promising platforms for quantum simulations[1]. In our lab, applying suitable local and global control fields on the trapped ions, we set up and tune increasingly complex quantum systems with a high level of control in a 2D array on a Surface electrode radio frequency trap and in a linear Paul trap. In our 2D array, we realize the Floquet-engineered coupling of adjacent sites through local manipulation of trapping potentials[2] and tuning of the system in real-time and interference of coherent states over large amplitudes[3]. Here, we also demonstrate the relocation of ions in a deterministic manner. In the Linear Paul Trap, we show the preparation of two ions in a squeezed state of motion featuring entanglement of the ions' motional degrees. This leads to the realization of an experimental analogue of the particle pair creation during cosmic inflation in the early universe[4]. In addition, we move towards the transfer of entanglement of motional degrees of freedom to internal degree of freedom.

[1] T. Schaetz et al., New J. Phs. 15, 085009 (2013)
[2] P. Kiefer et al., PRL 123, 213605 (2019)
[3] F. Hakelberg et al., PRL 123, 100504 (2019)
[4] M. Wittemer et al., PRL 123, 180502 (2019)

Q 8.31 Mon 16:30 Empore Lichthof

Programmable cooling on noisy quantum computers: Implementation and error analysis — •Imane El Achchi[1], Anne Matthies[1], Achim Rosch[1], Mark Rudner[2], and Erez Berg[3] — [1]Institute for Theoretical Physics, University of Cologne, 50937 Cologne, Germany — [2]University of Washington, Seattle, WA 98195-1560, US — [3]Weizmann Institute of Science, Rehovot, 76100, Israel

Recent advances in quantum computing provide a vast playground for the application of quantum algorithms on noisy intermediate-scale quantum devices. Here, we test the performance of the programmable adiabatic demagnetization protocol proposed in Ref. [1] on IBM's quantum devices. The cooling protocol prepares low-energy states for any gapped Hamiltonian independently of the system's initial state. Half the qubits simulate the system, and the other a bath in a strong Zeeman field, initialized in the polarized state. Entropy is transferred from the system to the bath by slowly decreasing the Zeeman field. Finally, the bath spins are measured and reset to the polarized state. The process is repeated throughout the protocol until a low-energy state of the system is reached. Cooling protocols are generally stable against low noise, making them a promising application for near-term quantum computers. We experimentally observe a cooling effect for the available small system size and limited gate depth on the IBM quantum device using quantum optimal control. Furthermore, we analytically analyze the dynamics of the cooling protocol to find a dark state of the corresponding quantum channel.

[1] arxiv: 2210.17256

Q 8.32 Mon 16:30 Empore Lichthof

Treating finite system-bath coupling using the hierarchy-of-pure-states approach — •Johann Assmus, Tobias Becker, and André Eckardt — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Open quantum system dynamics can be described by master equations for the system's reduced density matrix, however, the derivation of these equations often requires some assumptions like the Born-Markov-approximation. The hierarchy-of-pure-states approach is an alternative to master equations where the system is described by a stochastic ensemble of pure states and additional auxiliary states [1]. Since the dynamics of these pure states can be derived without any approximations, this approach is numerically exact. However, an approximation is made, by allowing for a finite number of auxiliary states. We compare the solutions of this method with the exact dynamics of a damped harmonic oscillator to examine its behaviour in regards to the number of hierarchies and other parameters.

[1] D. Süß, A. Eisfeld, W.T. Strunz, Phys. Rev. Lett. 113, 150403 (2014)

Q 8.33 Mon 16:30 Empore Lichthof

Quantisation and breakdown of topological transport in the Hubbard-Thouless pump — •Marius Gächter, Zijie Zhu, Anne-Sophie Walter, Konrad Viebahn, Stephan Roschinski, Joaquín Minguzzi, Kilian Sandholzer, and Tilman Esslinger — ETH, Zurich, Switzerland

Predicting the fate of topologically protected transport in the strongly correlated regime represents a central challenge within condensed matter physics. On the one hand, free-fermion energy bands and their geometric properties give rise to quantised transport phenomena, such as the quantum Hall effect and its dynamic analogon, the Thouless pump. The quantisation in these systems is considered robust against perturbations that commute with a protecting symmetry. On the other hand, interparticle interactions support strongly correlated states of matter, which often preclude particle transport, exemplified by the Mott transition in the Hubbard model. Will topology prevail in the presence of strong correlations? Here, we systematically probe the response of a topological Thouless pump to Hubbard interactions in an ultracold-atom experiment. We identify three distinct regimes, that is, pair pumping for strongly attractive interactions, quantised pumping for weak and moderate interactions, as well as the breakdown of transport for strong repulsive Hubbard U. Our experiments pave the way for investigating edge effects in interacting topological insulators, as well as interaction-induced topological phases with no counterpart in free-fermion systems.

Q 8.34 Mon 16:30 Empore Lichthof

Switching Topological State via Ferroelectric Polarization Field — •Jiabao Yang and Niels B. M. Schröter — Max-Planck-Institute of Microstructure Physics, Weinberg 2, 06120 Halle(Saale), Germany

The quantum spin hall insulator (QSHI) has shown great potential in low-dissipation spintronics and topological quantum computing, most of which highly rely on the emergency of topological edge state. Two common achieving methods, electric gating and strain effect are both challenging though the former requires continuous energy consumption and the latter needs precise control of strain. Two-dimensional(2D) ferroelectric material (FE), a kind of material with spontaneous and switchable charging polarization, can bring out a controllable topological order of 2D heterostructure when stacked with a heavy-element trivial insulator. The built-in electric field leads to new band alignment of the heterostructure, and band inversion occurs at the conduction band minimum of 2D FE and valence band maximum of TI. With the help of the robust interlayer spin-orbit coupling effect, the band gap can be opened. α-In2Se3, a typical ferroelectric material with a quite large polarizing built-in electric field(1.35eV), is an ideal substrate for monolayer WTe2. What is expected is the new topological state occurs in the van der Waals heterostructure around the gamma point and new non-volatile control of topological states.

Q 8.35 Mon 16:30 Empore Lichthof

Noise-assisted adiabatic quantum search algorithm: a study via quantum trajectories — •Raphaël Menu[1], Christiane P. Koch[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66123 Saarbr *ucken, Germany — [2]Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

Adiabatic quantum computing offers a precious alternative to quantum circuits for the implementation of quantum search algorithms. Indeed, while circuits require an oracle, namely a black box, to test whether the algorithm converged towards the target state, adiabatic quantum search algorithms performs the calculation via the adiabatic preparation of the ground state of a simple effective two-level system. Yet, such an approach is not flawless since it requires a large annealing time so that transitions out of the ground state are suppressed, and therefore one may reach time scales when the effects of the environment become relevant.

In this work, we study by the means of the framework of quantum trajectories (Monte Carlo wavefunction) the adiabatic implementation of the Grover search algorithm, and investigate how one can improve the performance of the search via the coupling of the computation qubit to an ancilla, leading to a shortest annealing time and a correction of the computational errors.

Q 8.36 Mon 16:30 Empore Lichthof

Microwave quantum memory based on rare earth doped crystal — •Jianpeng Chen[1,2,3], Ana Strinic[1,2,3], Achim Marx[1,2], Kirill G. Fedorov[1,2], Hans Huebl[1,2,3], Rudolf Gross[1,2,3], and Nadezhda Kukharchyk[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik department, Technische Universität München, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology, 80799 Munich, Germany

Quantum memory is essential in future quantum technologies, such as quantum computing circuits and quantum communication links. Specifically, Crystals doped with rare earth ions are promising competitive candidates due to their long coherence times [1] and potential multiplexing capability [2]. Here, we use a transmission line to couple microwave signals to rare earth ion dopants in yttrium orthosilicate crystals (Y2SiO5) at 10 mK. We present experimental results on storing coherent microwave states using the spin echo protocol. We will discuss the resulting coherence time and the impact of the transmission line design on the efficiency of the quantum information storage and its multimodality potential. We acknowledge financial support from the Federal Ministry of Education and Research of Germany (project number 16KISQ036). [1] Zhong, M, Nature 517, 177*180 (2015). [2] Antonio Ortu et al.Quantum Sci. Technol. 7 035024 2022.

Q 8.37 Mon 16:30 Empore Lichthof

Towards on-chip microwave-to-telecom transduction based on erbium-doped silicon — •Daniele Lopriore[1,2] and Andreas Reiserer[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]TU München and Munich Center for Quantum Science and Technology, 85748 Garching, Germany

The development of a device that converts microwave to optical photons at a telecommunication wavelength would be a key enabler for the communication between remote quantum computers. In this context, we are investigating erbium ensembles doped into nanophotonic silicon waveguides. This novel hardware platform features a unique combination of a small inhomogeneous broadening and an exceptional optical coherence even in nanostructured materials [1]. In an external magnetic field, the ground and excited states are split into doublets, which allows the erbium ensemble to act as the nonlinear medium mediating an efficient conversion process [2,3]. To this end, we plan to enhance both the microwave and the telecom transitions with resonators of high quality factor, fabricated on the same silicon chip. By optimizing the resonator geometries in order to maximize the overlap between the resonating fields and the erbium dopants, we aim to achieve transduction efficiencies approaching unity [3]. This would pave the way for the entanglement of superconducting qubits in remote cryostats.

[1] A. Gritsch, et al. Phys.Rev.X 12, 041009 (2022).
[2] L. Williamson, et al. Phys.Rev.Lett. 113, 203601 (2014).
[3] C. O'Brien, et al. Phys.Rev.Lett. 113, 063603 (2014).

Q 8.38 Mon 16:30 Empore Lichthof

Towards an efficient Quantum Network - Silicon Vacancy Color Centers in Diamond — •Donika Imeri[1,2], Tuncay Ulas[1], Sunil Kumar Mahato[1,2], and Ralf Riedinger[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg

Quantum networks combine a high level of security and the ability to scale up the qubit number which is crucial for quantum information processing. These networks contain nodes that store information. Quantum communication can be enabled by linking these nodes via entanglement. Silicon vacancy color centers in diamonds are promising components for optically connected quantum processors. The point defects establish an efficient optical interface and display a protective inversion symmetry. Therefore, the incorporation of nanophotonic structures, as well as coherent resonators, is possible. This can be used to generate entanglement between spin and photonic qubits. Long coherence times are a benefit, however, this includes the challenge of working in a cryogenic environment. Here, we present a platform to generate efficient and secure quantum communication by connecting multiple quantum processors.

Q 8.39 Mon 16:30 Empore Lichthof

Towards active stabilization of magnetic fields for trapped ions — •Lucas Eisenhart, Deviprasath Palani, Fabian Thielemann, Florian Hasse, Apurba Das, Ulrich Warring, Tobias Spanke, and Tobias Schaetz — Physikalisches Institut, Freiburg, Deutschland

When experimenting with trapped ions, it can be of great importance to generate magnetic fields that are highly stable, for example, when exploiting the electron degree of freedom in quantum applications. For this we characterize magnetic field sensors, with the help of which we may be able to adapt the coil current in our experiments to reduce field fluctuations. For magnetic field amplitudes in a range from 0.1G to 10^5G we use a Hall sensor with a sensitivity of 0.02mV/G and and a bandwidth that reaches up to 200kHz. For smaller magnetic field amplitudes in a range from 60μG to 10G we use a fluxgate sensor module that has a sensitivity of 1V/G and a bandwidth of up to 1kHz. We present our benchmark results of the hall- and fluxgate-sensor within our test environment.

Q 8.40 Mon 16:30 Empore Lichthof

High-order series expansions and crystalline structures for Rydberg atom arrays — •Duft Antonia, Jan Koziol, Matthias Mühlhauser, Patrick Adelhardt, and Kai Phillip Schmidt — Friedrich-Alexander-Universität Erlangen-Nürnberg

We investigate a model of hardcore bosons on the links of a Kagome lattice subject to a long-range decaying van-der-Waals interaction. This model is known to be the relevant microscopic description of Rydberg atom arrays excited by a detuned laser field which has been realized in experiments recently. Particular interest lies on this system as it is an engineerable quantum platform which has been predicted to to host a topological phase. We investigate the quantum phase diagram for different limiting cases with a main focus on the low interaction-strength limit where we apply high-order linked cluster expansions.

Q 8.41 Mon 16:30 Empore Lichthof

Numerical investigation of the Ising model in a light-induced quantized transverse field — •Anja Langheld and Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, Staudtstraße 7, Friedrich-Alexander Universität Erlangen-Nürnberg, D-91058 Erlangen, Germany

We investigate the Ising model in a light-induced quantized transverse field [1] with a particular focus on antiferromagnetic, potentially frustrated Ising interactions. Using exact diagonalization, we provide data for the antiferromagnetic chain in a longitudinal field that is inconsistent with earlier results coming from mean-field considerations [2]. In order to study the model on frustrated, two-dimensional lattice geometries, we extend the mean-field calculation and develop a quantum Monte Carlo update based on the recently introduced wormhole update [3], for which the photons are integrated out. By this means, the photons induce a retarded spin-spin interaction in imaginary time that is also non-local in space in contrast to the Ising interaction inherent to the model.

[1] J. Rohn et al., Phys. Rev. Research 2, 023131 (2020)
[2] Y. Zhang et al., Sci Rep 4, 4083 (2014)
[3] M. Weber et al., Phys. Rev. Lett. 119, 097401 (2017)

Q 8.42 Mon 16:30 Empore Lichthof

Luttinger's Theorem in the One-Dimensional tJ-model — •Annika Böhler[1,2], Henning Schlömer[1,2], and Fabian Grusdt[1,2] — [1]Ludwig-Maximilians University, Munich, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany

The Hubbard model in one dimension is known to exhibit spin charge separation, which has recently been observed in settings of ultracold fermions in optical lattices. Another signature of spin-charge separation in a lattice, that has not been directly observed thus far, is constituted by a change of the Fermi momentum. Luttinger's theorem relates the volume of the Fermi surface - and therefore the Fermi momentum - to the underlying particle density of the system. Here we discuss a proof of the theorem [M. Oshikawa, Phys. Rev. Lett. 84 (2000), 3370] in the presence of spin charge separation and evaluate whether it provides a tool to distinguish between qualitatively distinct spin-1/2 liquids and spinless chargon liquids via their different Fermi momenta. We show that Friedel oscillations of the density at the edge of a system can be used to directly observe the change of Fermi momentum, reflecting a qualitative change in the nature of charge carriers which we associate with an emergent U(1) symmetry corresponding to the total number of holes in the large-U limit of the Hubbard model.

Q 8.43 Mon 16:30 Empore Lichthof

Guided variational quantum algorithm for time evolution in dynamical mean field theory — •Stefan Wolf[1], Michael J. Hartmann[1], and Martin Eckstein[2] — [1]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg — [2]I. Institute of Theoretical Physics, Department of Physics, University of Hamburg

Dynamical mean-field theory (DMFT) is a useful tool to treat models of strongly correlated fermions like the Hubbard model. The lattice of the model is replaced by a single-impurity site embedded in an effective bath. The resulting single impurity Anderson model (SIAM) can then be solved self-consistently with a quantum-classical hybrid algorithm. This procedure involves repeatedly preparing the ground state on a quantum computer and evolving it in time. We propose an approximation of the time evolution operator by a Hamiltonian variational ansatz. The parameters of the ansatz are obtained via a variational quantum algorithm that utilizes a small number of Trotter steps, given by the Suzuki-Trotter expansion of the time evolution operator, to guide the evolution of the parameters. The cost function is evaluated by measuring a single ancilla qubit using the Hadamard test, thus reducing the required number of measurements compared to other approaches. The resulting circuit for the time evolution is shallower than a comparable Suzuki-Trotter expansion. We show results for two-site DMFT with half-filling. We further looked into the possibility to extend the approach for the impurity model with more than one bath site and away from half-filling.

Q 8.44 Mon 16:30 Empore Lichthof

Measurement Induced State Preparation — •Daniel Alcalde Puente — PGI8, Wilhelm-Johnen-Straße 52428 Jülich

This work explores the protocol proposed in (Roy, Sthitadhi, et al. "Measurement-induced steering of quantum systems." Physical Review Research 2.3 (2020): 033347) for state preparation outside of the Lindblad limit. In this protocol, a system is coupled to ancillas with a time-independent Hamiltonian, with the ancillas being periodically reset. The protocol exploits the frustration-free nature of the parent Hamiltonian, enabling the writing of local operators that map from locally excited states to locally unexcited states. The full dynamics of this protocol are simulated using Matrix Product States and quantum trajectories, and the behavior of the protocol is analyzed for different measurement intervals. In particular, our study explores the case of preparing the spin-1 Affleck-Kennedy-Lieb-Tasaki state and discusses the protocol's resilience to errors. The results show that the dynamics of the protocol match the dynamics of the Lindblad limit for relatively large measurement intervals, that the optimal measurement interval is close to the expected ideal measurement interval, and that the protocol converges even for large measurement intervals, though only slowly.

Q 8.45 Mon 16:30 Empore Lichthof

Portfolio Optimization using a Quantum Computer — •Matthias Hüls and Daniel Braun — Institut für Theoretische Physik, Eberhard Karls Universität Tübingen, Deutschland

Entering the era of Noisy Intermediate-Scale Quantum (NISQ) devices, hopes are raising to already make practical use of the existing quantum processors. While deep algorithms still fail on the error prone hardware, variational algorithms show error resilience to some extend. This makes them well suited for the NISQ technology. Therefore, popular candidates like the Quantum Approximate Optimization Algorithm (QAOA), designed to solve combinatorial optimization problems, attracted much attention in recent years. In a case study, we benchmark the performance of the QAOA for the portfolio optmimization problem. We focus on how the characteristics of a given problem instance influence the algorithms performance and deduce a criterion for distinguishing between 'easy' and 'hard' instances.

Q 8.46 Mon 16:30 Empore Lichthof

Performance of Grover's Algorithm on IBM Quantum Processors — •Yunos El Kaderi[1,2], Andreas Honecker[1], and Iryna Andriyanova[2] — [1]LPTM UMR CNRS 8089, CY Cergy Paris Université, France — [2]ETIS UMR CNRS 8051, CY Cergy Paris Université, France

This work tests the performance of Grover search circuits on the available IBM superconducting quantum devices that are accessible on the IBMQ cloud. Ideally, we expect to get a probability distribution that is clearly peaked at the targeted state. However, the quantum circuit executed on NISQ devices is vulnerable to noise which leads to fluctuations in the expected results. This depends on the quality of the device which is defined by a Quantum Volume parameter and on the depth of the circuit. Some previous works reached results that are completely noisy with no useful information, see for example Ref. [1] for 4 qubits (16 elements). Here we show that suitable implementations on concurrent IBMQ devices can actually yield useful results and explore the limitations.

[1] Y. Wang, P.S. Krstic, Phys. Rev. A **102**, 042609 (2020)

Q 8.47 Mon 16:30 Empore Lichthof

QVLS Q1 supporting experiment for development of techniques for ion transport and sympathetic cooling — •Christian Joohs[1,2], Markus Duwe[1,2], Yannick Hermann[1,2], Ludwig Krinner[1,2], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]PTB, Bundesallee 100, 38116 Braunschweig

Within the ongoing development of the ion-based quantum computer Q1 carried out by QVLS (**Q**uantum **V**alley **L**ower **S**axony), a supporting experiment is being built and used for research and development of transport and cooling techniques. The trap is experimentally realised by a surface electrode Paul trap, which allows movement of trapped ions in a two-dimensional space above the trap. This possibility is used to realise the computer in a register-like fashion (termed QCCD architecture [1,2]) by having different zones on the trap chip that account for different tasks including storage, readout, and quantum logic gate application. A key aspect therefore is the development of ion transport techniques between said zones while maintaining a low heating rate and without interruption of the ion's electronic quantum state. Furthermore, we study the possibility to sympathetically cool two logic ions with a single cooling ion of significantly heavier mass. We report on previous progress and goals.

[1] D.J. Wineland *et al.*, J. Res. Natl. Inst. Stand. Technol. **103**, 259 (1998)
[2] D. Kielpinski, C. Monroe, and D. J. Wineland, Nature **417**, 709 (2002)

Q 8.48 Mon 16:30 Empore Lichthof

Towards a fault tolerant microwave-driven two qubit quantum processor — •Markus Duwe[1,2], Hardik Mendpara[1,2], Nicolas Pulido-Mateo[1,2], Ludwig Krinner[1,2], Giorgio Zarantonello[3], Amado Bautista-Salvador[1,2], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig — [3]National Institute of Standards and Technology, Boulder, USA

A universal quantum gate set can be realized by the combination of single-qubit gates and one entangling operation. In this work, we realize such a gate set using the microwave near field approach [1]. We trap two 9Be+ ions in a radio-frequency surface electrode trap and perform the quantum logic operations with embedded microwave conductors. The individual qubits are addressed by micromotion sidebands [2] and the entangling gate is performed via a Mølmer-Sørensen type interaction. We approach an infidelity of 10^{-4} with single qubit gates and 10^{-3} with entangling gates using partial tomography [3]. We report on challenges and solutions for further improving the gate fidelities and to characterize gate errors.

[1] C. Ospelkaus *et al.*, Phys. Rev. Lett. **9**, 090502 (2008)
[2] U. Warring *et al.*, Phys. Rev. Lett. **17**, 173002 (2013)
[3] M. Duwe *et al.*, Quantum Sci. Technol. **7**, 045005 (2022)

Q 8.49 Mon 16:30 Empore Lichthof

Next generation platform for implementing fast gates in ion trap quantum computation — •Donovan Webb, Sebastian Saner, Oana Bazavan, Mariella Minder, and Christopher Ballance — University of Oxford

Scalable trapped-ion quantum computation relies on the development of high-fidelity fast entangling gates in a many ion crystal. Conventional geometric phase gates either suffer from scattering errors or off-resonant carrier excitations. A potential route to achieve fast entanglement is creating a standing wave which can suppress the unwanted carrier coupling [Mundt 2003].

We present the roadmap to our next-generation platform tailored for fast gates in the ~1μs regime where gate speeds become comparable to the secular trap frequency. The quadrupole transitions between S1/2 and D5/2 levels in Calcium 40 will be driven to perform Molmer-Sorenson gates with a standing wave rather than a typical travelling wave. The off-resonant carrier excitation may be strongly suppressed by placing ions at the nodes of the optical lattice. This new platform has scope for a multi-ion chain and a corresponding array of optical lattices which each address a single ion. The lattice array is created by a set of counter-propagating beams which are tightly focused by a symmetric setup of high-NA lenses. Control of the optical phase at the ion site will be achieved by actively stabilising the counter-propagating beam interferometer and feedbacking on the ion signal.