QI 14: Quantum Information Poster Session

Time: Wednesday 18:00–21:00 Location: P4

QI 14.1 Wed 18:00 P4

An Efficient Error Correction Protocol Variant for Field Tests of Continuous-Variable Quantum Key Distribution — Lukas Eisemann[1,2], •Stefan Richter[1,2], Hüseyin Vural[1,2], Ömer Bayraktar[1,2], Kevin Jaksch[1,2], and Christoph Marquardt[1,2] — [1]Chair of Optical Quantum Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7 / A3, Erlangen — [2]Max Planck Institute for the Science of Light, Staudtstr. 2, Erlangen

Continuous-variable quantum key distribution (CV-QKD) requires near-optimally efficient information reconciliation (IR) to achieve high secret key rates (SKR) and transmission distances. Here, we present a novel and improved variant of a recently introduced IR-protocol, which is based on multiple decoding attempts (MDA). We evaluate our method on simulated data sets and employ it in the IR step for our fiber-based discrete-modulated CV-QKD system, which we deployed during a large-scale public technology demonstration in Berlin. In each instance, we observe meaningful key rate improvements over both the ubiquitous single decoding attempt protocol and the original MDA implementation, even at a fixed decoding complexity. We also discuss some of the practical challenges associated with CV-QKD deployments in real networks outside of a lab context, arguing that the adaptability of our method makes it well-suited to solve them, providing implementation benefits in the process.

QI 14.2 Wed 18:00 P4

Entanglement with a mode observable via a tunable interaction with a qubit — •Malgorzata Strzalka[1,2], Radim Filip[3], and Katarzyna Roszak[1] — [1]FZU - Institute of Physics of the Czech Academy of Sciences,. — [2]Faculty of Mathematics and Physics, Charles University. — [3]Department of Optics, Palacký University.

We propose a qubit-environment entanglement (QEE) detection scheme for time dependent pure dephasing Hamiltonians. We study the entanglement for a transmon qubit interacting with an environment of microwave cavity photons. The QEE detection schemes that were previously developed for interactions that lead to pure decoherence of the qubit are based on measurements and operations performed only on the qubit alone [1]. Yet they could not be used in the studied scenario because of inherent symmetries in the Hamiltonian. We show that it is possible to override this problem by using different Hamiltonias in the preparation and the measurement stage. We take advantage of the possibility of tuning of the qubit-environment coupling to detect entanglement. Qubit-oscillator entanglement is seen to play a essential role in developing bosonic quantum technology. We previously studied the evolution of QEE for the same system [2] and now we present how the developed detection scheme can signify this type of entanglement. The scheme can be also used for other systems, where the decoherence is predominantly pure dephasing.

[1] M. Strzalka and K. Roszak, Phys. Rev. A 104, 042411 (2021).
[2] M. Strzalka et al. Phys. Rev. A 109, 032412 (2024).

QI 14.3 Wed 18:00 P4

Non-perturbative approach to entanglement harvesting — •Fabian Ganzer, Mei Yu, and Walter Strunz — Institute for Theoretical Physics, TU Dresden

It has been shown that two localized quantum systems like qubits or atoms can harvest entanglement from a quantum vacuum field through local interactions [1]. This phenomenon is often interpreted as a buildup of quantum correlations that can be established faster than with the speed of light due to a vacuum field. To date, however, most investigations have relied on perturbative approaches, leaving the genuine non-perturbative dynamics largely unexplored. In this work, we study entanglement harvesting using the non-perturbative numerical uniTEMPO method [2], enabling us to access both the weak- and strong-coupling regimes. Our results demonstrate that reliable statements about entanglement harvesting require both, a non-perturbative method and a careful analysis of correlations, particularly quantum correlations.

[1] C. Sabín, J. J. García-Ripoll, E. Solano, and J. León, Dynamics of entanglement via propagating microwave photons, Phys. Rev. B 81, 184501 (2010)
[2] V. Link, H.-H. Tu and W. T. Strunz, Open quantum system dynamics from infinite tensor network contraction, Phys. Rev. Lett. 132, 200403 (2024)

QI 14.4 Wed 18:00 P4

Simulating and Utilizing Dissipative Non-Equilibrium Physics on NISQ Devices — •Rochus Lechler[1], Pascal Stadler[2], Jan Reiner[2], Dominik Maile[1], Michael Marthaler[2], and Joachim Ankerhold[1] — [1]Institute for Complex Quantum Systems, Ulm University, Ulm — [2]HQS Quantum Simulations GmbH, Karlsruhe

Driven dissipative quantum many-body systems hold a variety of interesting phenomena like dissipative quantum phase transitions and non-equilibrium steady states. Typically, the full theoretical understanding of these phenomena is hindered by complex dynamics in large Hilbert spaces. Within this context, quantum simulation is a promising alternative bridging the gap between theory and experiment. Our project aims at finding efficient ways to simulate dissipative and driven many-body systems on NISQ devices. To this end, we make use of a software package provided by HQS Quantum Simulations capable of simulating complex open quantum systems. The key idea of this approach is to view quantum hardware itself as being a driven dissipative many-body system. More specifically, we utilize the noise on the hardware to engineer the required decoherence processes for the system under study. Building up on recent theoretical advances we show how to reduce the resources needed for these simulations.

QI 14.5 Wed 18:00 P4

Entanglement generation in quantum networks driven by multi-mode squeezed radiation — •Miguel Angel Palomo Marcos[1,2], Franz Pöschl[1,2], and Peter Rabl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, D-85748 Garching, Germany — [2]School of Natural Sciences, Technische Universität München, D-85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology, D-80799 Munich, Germany

The development of scalable and efficient entanglement generation schemes is of central importance for the practical realization of quantum computing. Conventional approaches suffer from cumulative gate errors and decoherence, which have motivated the search for more scalable and robust protocols. Here we propose and analyze a quantum network, where a set of distant qubits is illuminated by multi-mode squeezed radiation. The dissipative dynamics drives the system into a stationary entangled state. We discuss different phase space techniques to numerically simulate this system for a large number of qubits and photonic modes and characterize the resulting entanglement generation properties for different parameter regimes.

QI 14.6 Wed 18:00 P4

Non-Markovian bound-state formation in a giant atom with two coupling points — •Mei Yu[1], Stefan Nimmrichter[2], and Walter Strunz[1] — [1]TUD Dresden University of Technology, — [2]University of Siegen

Superconducting qubits coupled to meandering transmission lines or to surface acoustic waveguides can realize giant artificial atoms, whose interaction with the waveguide occurs at multiple, spatially separated coupling points. Such a geometry introduces well-controlled propagation delays between the coupling points and thereby enables strongly non-Markovian dynamics with memory effects beyond the atomic lifetime [1, 2]. In this work, we investigate the relaxation dynamics of a single giant atom coupled to a one-dimensional acoustic waveguide through two coupling points in the strong-coupling regime. We show that interference between the delayed feedback channels leads to the formation of a bound state embedded in the continuum of waveguide modes, which in turn results in partial population trapping within the giant atom.

[1] L. Guo, A. Grimsmo, A. F. Kockum, M. Pletyukhov, and G. Johansson, Giant acoustic atom: A single quantum system with a deterministic time delay, Phys. Rev. A 95, 053821 (2017).
[2] G. Andersson, B. Suri, L. Guo, T. Aref, and P. Delsing, Non-exponential decay of a giant artificial atom, Nature Physics 15, 1123 (2019).

QI 14.7 Wed 18:00 P4

Entanglement distillation of microwave entangled states

— •Ivan Solomakhin[1,2], Simon Gandorfer[1,2], Maria-Teresa Handschuh[1,2], Jasmine Frijters[1,2], Wun Kwan Yam[1,2], Achim Marx[1,2], and Kirill G. Fedorov[1,2,3] — [1]Walther-Meißner- Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]School of Natural Sciences, Technische Universität München, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

Quantum entanglement is a crucial resource in continuous-variable quantum protocols, such as quantum teleportation and quantum key distribution. However, as the communication distance and complexity increase, losses due to unavoidable imperfections along the signal path lead to the degradation of shared entanglement and diminish the protocol performance. This challenge motivates the development and optimization of entanglement distillation strategies. Here, we investigate experimental implementations of entanglement distillation based on photon-subtraction techniques in application to two-mode squeezed, path-entangled microwave states. We employ superconducting Josephson amplifiers for the generation of two-mode squeezed states. Photon subtraction is realized by using a single-photon microwave detector composed of a transmon qubit in a multimode cavity. We analyze the resulting improvement in entanglement and discuss its implications for quantum communication and quantum networks in the microwave regime.

QI 14.8 Wed 18:00 P4

Noise mitigation in microwave quantum key distribution using single-photon detection — •Jasmine Frijters[1,2], Ivan Solomakhin[1,2], Simon Gandorfer[1,2], Wun Kwan Yam[1,2], Maria-Teresa Handschuh[1,2], Achim Marx[1], and Kirill G. Fedorov[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]School of Natural Sciences, Technical University of Munich, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

Quantum key distribution (QKD) is a cryptographic protocol that allows for the unconditionally secure exchange of secret keys between two parties. While QKD implementations in the optical domain are rapidly developing toward practical applications, we analyse a continuous-variable microwave QKD protocol that utilizes single-photon detection to increase the secure transmission distance in both direct and reverse reconciliation schemes. In view of current experimental capabilities for microwave QKD, we predict an increase of up to 80% in secure transmission distance and estimate a key distribution of more than 300 m.

QI 14.9 Wed 18:00 P4

Bounds on quantum conference key agreement in networks with bipartite links — •Justus Neumann, Anton Trushechkin, Hermann Kampermann, and Dagmar Bruss — Heinrich Heine Universität Düsseldorf

Quantum conference key agreement allows several users to establish a shared secret key. A common approach is to use multipartite entangled states like Greenberger-Horne-Zeilinger states, but these are difficult to create in real networks. We instead consider a more practical setting where only two-party entangled states are available between network nodes, and users can only perform local measurements followed by classical communication, without quantum memory. We study the general conference key agreement problem and derive a fundamental upper bound on the achievable key rate. We prove that, in any network composed only of bipartite sources, one cannot outperform a simple strategy: perform ordinary two-party quantum key distribution between one user and each of the others, and then merge the pairwise keys into a common conference key. This shows that complex multipartite strategies offer no rate advantage in such networks.

QI 14.10 Wed 18:00 P4

Entanglement of Electron and Nuclear Spins in Diamond — •Magnus J. R. Platena, Marius M. Strassner, Tim C. Duka, and Martin S. Brandt — Walter Schottky Institut, TU München, Am Coulombwall 4, 85748 Garching

Entanglement is one of the most surprising and counterintuitive phenomena of quantum physics. Nitrogen-vacancy (NV) centers in diamond provide a platform for studying this phenomenon at room temperature, a unique advantage of this solid-state system. The goal of this work is to demonstrate and quantify the entanglement of electron spins and ^{15}N nuclear spins in ensembles of NV centers via optically detected magnetic resonance. In a first step, we characterize isotopically engineered diamonds as a function of ^{15}N concentration, electron irradiation, and annealing and reproduce the published dependence of T_2 and T_2^* on nitrogen concentration. With the help of electron nuclear double resonance, we entangle the two spins and quantify the entanglement via quantum state tomography and application of the Peres criterion.

QI 14.11 Wed 18:00 P4

Differential magnetometry with partially flipped Dicke states — •Iagoba Apellaniz[1,2], Manuel Gessner[3], and Géza Tóth[1,2,4,5,6] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, P. O. Box 644, ES-48080 Bilbao, Spain — [2]EHU Quantum Center, University of the Basque Country UPV/EHU, P.O. Box 644, E-48080 Bilbao, Spain — [3]Departament de Física Teòrica, IFIC, Universitat de València, CSIC, Carrer del Dr. Moliner 50, 46100 Burjassot (València), Spain — [4]Donostia International Physics Center DIPC, Paseo Manuel de Lardizabal 4, San Sebastián, E-20018, Spain — [5]IKERBASQUE, Basque Foundation for Science, E-48009 Bilbao, Spain — [6]HUN-REN Wigner Research Centre for Physics, P.O. Box 49, H-1525 Budapest, Hungary

Dicke states on two ensembles can be sensitive to magnetic gradients by locally rotating the spins on one well. We determine bounds for the precision for gradient metrology in the three orthogonal directions as a function of the sensitivities of the homogenous field. The resulting partially flipped Dicke state saturates these bounds. Exploiting entanglement between the two ensembles, this state achieves roughly twice the precision attainable by the best bipartite separable state, which is a product of local Dicke states. For small ensembles, we explicitly identify measurement operators saturating the quantum Cramér-Rao bound, while for larger ensembles, we propose simpler schemes. The gradient is estimated from second moments of local angular momentum operators. Our results demonstrate how metrological properties of Dicke states can be exploited for quantum-enhanced estimation.

QI 14.12 Wed 18:00 P4

Calculation of Binding Energies for a Total of 25 Nuclei Between 2 and 12 nucleon Nuclei Using the Quantum Computer VQE Algorithm — •Taylan BAŞKAN and Ahmet Hakan YILMAZ — Faculty of Sciences, Department of Physics, Karadeniz Technical University, Trabzon, 61080 Turkey

In this study, the binding energies of the first 25 nuclear nuclei were calculated using a quantum computer simulator provided by IBM. These 25 nuclei include nuclei with a nucleon number of 12 and their isotopes, from hydrogen to oxygen. The VQE (variational quantum eigensolver) algorithm was used in the calculation process. The Hamiltonian designed for this purpose was designed to cover all nuclei. This developed a basic approach encompassing light nuclei and generated a model for estimating binding energies. The binding energies of the nuclei were obtained with an average deviation of 17% from known experimental values. For the VQE algorithm, a pre-written Hamiltonian was mapped to the quantum computer and determined by selecting ansatz and minimizing eigenvalues.

QI 14.13 Wed 18:00 P4

Quantum error mitigation on a bosonic quantum processing unit — •Corvin Lenz[1], Tanay Roy[2], Yao Lu[2], and Peter Orth[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Superconducting Quantum Materials and Systems Division, Fermi National Accelerator Laboratory, Batavia, IL 60510, USA

Bosonic processing units offer a scalable platform for continuous-variable quantum computation, but their interaction with noisy ancillary systems introduces significant errors that must be mitigated for reliable performance.

In this work, we simulate a bosonic qudit dispersively coupled to a two-level transmon, controlled via pulse-based external drives. Using process tomography on a synthesized, universal gate set, we characterize gate-dependent error channels arising from transmon-induced noise. We then apply probabilistic error cancellation (PEC) as an error mitigation technique, which reduces the impact of noise without relying on full fault-tolerant schemes.

Our results demonstrate a substantial improvement in individual gate performances, highlighting the effectiveness of PEC for error mitigation.

QI 14.14 Wed 18:00 P4

Efficient Spin-Adapted QPE Initial State Preparation —
•Hampus Brunander[1,2] and Werner Dobrautz[1,2,3,4] — [1]Center for Advanced Systems Understanding, 02826 Görlitz, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [3]Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 01069 Dresden, Germany — [4]Technical University Dresden, 01069 Dresden, Germany

The performance of quantum algorithms for strongly correlated electronic systems hinges on the overlap between the initial trial wavefunction and the ground state. However, a critical trade-off exists: the circuit cost of state preparation must not outweigh the algorithmic advantage. We address this by identifying regimes where problem-specific preparations yield high overlaps with minimal circuit depth. By adapting classical spin-group approaches, we utilize Localized Orbitals (LOs) to identify the optimal spin-coupling ordering. This chemically motivated approach constructs a dominant spin-adapted state that maximizes overlap while ensuring a compact, hardware-efficient implementation. We demonstrate that this strategy significantly improves fidelity for challenging systems, such as the stretched nitrogen dimer and iron-sulfur clusters.

QI 14.15 Wed 18:00 P4

Superconducting Digital-Analog Circuits for Quantum Approximate Optimization — •Siyu Wang and Mohammad H. Ansari — Forschungszentrum Juelich, 52425 Juelich, Germany

Digital-analog quantum algorithms such as the digital-analog Quantum Approximate Optimization Algorithm (DA-QAOA) offer a scalable approach to quantum optimization by combining digital gate-based control with native analog evolution. In this work, we aim to explore a quantum processor architecture that supports DA-QAOA using the multi-mode superconducting resonator as the analog interaction resource.

The structure leverages the finite-mode resonator to enable effective ZZ-type interactions between different pairs of qubits without requiring tunable couplers. Single-qubit gates are applied digitally via dedicated drive lines, enabling a clear separation between analog and digital layers. This approach naturally realizes qubit interactions, thus eliminating the need for SWAP operations that are typically required in digital only architectures with limited connectivity, thereby reducing the circuit depth. The goal is to identify a layout and interaction scheme that preserves the essential properties of DA-QAOA while remaining fabrication-friendly and scalable to larger systems.

Our findings provide a design framework for implementing variational quantum algorithms in NISQ hardware using fewer resources.

QI 14.16 Wed 18:00 P4

Mitigating Noise in Quantum-Classical Electronic Band Structure Calculations — •Vojtěch Vašina[1,2] and Martin Friák[1] — [1]Institute of Physics of Materials, Czech Academy of Sciences, Brno, Czech Republic — [2]Brno University of Technology, Institute of Material Sciences and Engineering

Computational materials science is currently facing a significant scalability issue. Simulating large condensed matter systems requires immense computational resources because the computational complexity grows exponentially as the size of the system increases. Quantum computers are emerging as a possible solution to overcome this problem because they theoretically offer up to an exponential speedup for certain problems. Current Noisy Intermediate-Scale Quantum (NISQ) computers are too noisy to provide results that are sufficiently accurate so classical and quantum algorithms are combined into so-called quantum-classical hybrid algorithms to overcome high levels of noise. In our study, we focused on computing the electronic band structure of diamond as this problem is well known and can be accurately solved on classical computers allowing us to compare those results to results obtained from the Variational Quantum Deflation (VQD) algorithm. We specifically investigate different error suppression and error mitigation techniques because the fidelity of results sensitively depends on them. The quantum parts of the VQD algorithm were executed on real quantum computers provided by IBM.

QI 14.17 Wed 18:00 P4

Effects of geometry on the error threshold of the toric code — •Daniel Lessing, Calvin Kraemer, Jan Alexander Koziol, Anja Langheld, and Kai Phillip Schmidt — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany

The Random-Bond Ising Model can serve as a theoretical model for determining the error threshold of the toric code. This threshold is the maximum physical error rate tolerable for fault-tolerant quantum computation. We employ Monte Carlo Integration combined with finite-size scaling to map the RBIM's phase boundary for different temperatures and antiferromagnetic bond concentrations, which correspond to the different error rates in the toric code. The intersection of this phase boundary with the Nishimori line directly defines the critical error threshold for the toric code. Our investigation determines how this critical error threshold is influenced by varying the underlying geometry of the lattice.

QI 14.18 Wed 18:00 P4

Effect of Long-range Crosstalk Errors on the Surface Code — •Solomon Birhanu Samuel[1] and Janos Karoly Asboth[1,2,3] — [1]Department of Theoretical Physics, Institute of Physics, Budapest University of Technology and Economics, Muegyetem rkp. 3., H-1111 Budapest, Hungary — [2]HUN-REN Wigner Research Centre for Physics, H-1525 Budapest, P.O. Box 49., Hungary — [3]HUN-REN-BME-BCE Quantum Technology Research Group, Muegyetem rkp. 3., H-1111 Budapest, Hungary

Crosstalk errors (due to unintended interactions between qubits and coupling between different circuit elements) pose a challenge to quantum error correction. They are often assumed to only affect nearest or next-nearest neighbor qubits[1], but experiments on some superconducting quantum processors[2] show that they can occur between more distant qubits as well. In this work, we study the effect of longer-range crosstalk errors on the surface code using numerical models (Clifford simulation) with realistic parameters of superconducting chips. We use Pauli error models to simulate the effect of the crosstalk both on the threshold and the logical error rate below threshold.

[1] Zhou, Zeyuan, Andrew Ji, and Yongshan Ding. "Surface Code Error Correction with Crosstalk Noise." arXiv preprint arXiv:2503.04642 (2025).

[2] Kosen, Sandoko, et al. "Signal crosstalk in a flip-chip quantum processor." PRX Quantum 5.3 (2024): 030350.

QI 14.19 Wed 18:00 P4

Hybrid Quantum-Classical Walks with Applications to Machine Learning — •Adrián Marín Boyero[1], Daniel Manzano Diosdado[1], and Carlos Cano Gutiérrez[2] — [1]Department of Electromagnetism and Condensed Matter Physics, Avenida de la Fuente Nueva, 18071 Granada, University of Granada, Granada, Spain — [2]Institute Carlos I for Theoretical and Computational Physics, Avenida de la Fuente Nueva, 18071 Granada, University of Granada, Granada, Spain

Complex systems can often be described as networks, where nodes represent elements and edges represent interactions. Classical Random Walks (CRWs) are widely used for machine learning tasks on such structures. In this work, we introduce a Hybrid Quantum-Classical Walk (HQCW) model based on a modified Lindblad equation. This framework interpolates between quantum coherence and classical jumps through a parameter $\alpha \in [0, 1]$, generating node-visit trajectories whose statistics recover the Lindblad dynamics. The trajectories are generated with a Monte Carlo method known as Quantum Jumps, which reproduces the statistics of the underlying open system evolution. We use these trajectories for Graph Representation Learning and show that HQCWs break node ranking degeneracies, correctly recover communities, and separate node clusters in synthetic networks, even at low embedding dimension d. Performance peaks in a near-classical regime ($\alpha \approx 0.8$), capturing the global graph structure effectively. Our results highlight HQCWs as a scalable quantum-inspired tool for network analysis and machine learning.

QI 14.20 Wed 18:00 P4

GRAPE with feedback: the method and the Python package — •Pavlo Bilous[1] and Florian Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

Quantum control with feedback is an essential component of modern quantum technology applications. While open-loop control tasks are usually solved using gradient methods like GRadient Ascent Pulse Engineering (GRAPE), it was until recently not clear how feedback from measurements in the control process can be integrated in these methods. Here, we discuss the "Feedback GRAPE" method introduced recently in Ref. [1] where feedback is combined with GRAPE

using machine learning techniques. Given the potential use of "Feedback GRAPE" for the community, we developed an efficient GPU-accelerated Python package implementing the approach. Here we discuss our codes and showcase them on three main closed-loop tasks: state preparation with feedback, state purification and state stabilization. Using the presented examples as the starting point, the users can conveniently apply our package for their problem at hand.

[1] R. Porotti, V. Peano, and F. Marquardt, PRX Quantum 4, 030305 (2023).

QI 14.21 Wed 18:00 P4

Characterization of spin-relaxation dynamics of rare earth ions in $CaWO_4$ — •Sebastian Dominguez-Calderon[1,2], Georg Mair[1,2], Arjun Bhasker[1,2], Robert Pant[1,2], Hans Huebl[1,2,3], and Nadezhda Kukharchyk[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, D-85748 Garching, Germany — [2]School of Natural Sciences, Technische Universität München, D-85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology, D-80799 Munich, Germany

Rare-earth spin ensembles doped into bulk crystals, such as $CaWO_4$, are promising candidates for quantum memory devices operating at microwave frequencies and compatible to superconducting quantum technologies. To further improve this technology, it is of pivotal importance to understand the mechanisms which affect information lifetimes. In the present work, we investigate spin interactions in ensembles of rare-earth (RE) ions in $CaWO_4$ via superconducting coplanar waveguides at millikelvin temperatures. Using spatially separated transmission lines, as well as pump-probe detection schemes, we aim to understand the ensemble's spin diffusion, suspected to be dominated by spin-spin as well as spin-phonon interactions. Characterization of the diffusion will give insights into different relaxation channels for RE:$CaWO_4$ that would aid the design of future quantum memory devices.

QI 14.22 Wed 18:00 P4

Qubit analogues in exciton-polariton condensates with optical manipulation — •Roman Lebs[1], Jan Wingenbach[1,2], Hendrik Rose[2], and Stefan Schumacher[1,2] — [1]Physics Department and CeOPP, Paderborn University, Germany — [2]PhoQS, Paderborn University, Germany

Exciton-polariton condensates provide a promising platform for quantum information processing, offering long coherence times, robust information storage and operation up to room temperature. Here we build upon earlier demonstrations of vortex-based information encoding (Ma et al., Nat. Commun. 11, 897, 2020), split ring qubit analogues (Xue et al., Phys. Rev. Research 3, 013099, 2021), and recent progress toward polaritonic qubit prototypes in annular traps (Barrat et al., Science Advances 10, eado4042, 2024), investigating a polariton condensate as a fully optically controllable qubit analogue. The condensate dynamics are modelled using the nonlinear Gross-Pitaevskii equation and numerically solved with PHOENIX, a highly optimized CUDA accelerated solver for two-dimensional nonlinear Schrödinger equations (Wingenbach et al., Comput. Phys. Commun. 315, 109689, 2025), which enables efficient and high-resolution simulations. We show that all points of the Bloch sphere can be reached by encoding the $|0\rangle$ and $|1\rangle$ states as localized spatial profiles with distinct phases. A simple pump geometry, combining a ring pump and a Gaussian pump applied on the ring, allows precise control of trajectories on the Bloch sphere. We also outline how this scheme can be extended toward coupled condensates in multi qubit architectures.

QI 14.23 Wed 18:00 P4

Si/SiGe interfaces for scalable qubit devices - a depth resolved HAXPES study — •Nathalie Niederbudde[1], Andreas Fuhrberg[1], Denny Dütz[2], Andrej Gloskovskii[3], Christoph Schlueter[3], Lars R. Schreiber[2], and Martina Müller[1] — [1]Universität Konstanz — [2]RWTH Aachen University — [3]DESY, Hamburg, Germany

An ongoing challenge in quantum physics research is optimizing the performance of silicon-based spin qubits. These devices use the intrinsic spin of electrons as logic states. The electron location is electrostatically controlled by biased gate pattern on top of the device. A common spin qubit platform compatible with industrial processes is based on SiGe/Si/SiGe heterostructures, where the electron is trapped in the strained Si layer. To achieve reliable control of the trapping potential, defects occurring mainly at the Si-capping layer and the amorphous gate-oxide must be explored, studied and minimized.

This study investigates an Al_2O_3/Si/SiGe-qubit structure using hard X-ray photoelectron spectroscopy (HAXPES) with synchrotron radiation of 2.8 & 6 keV at beamline P22, DESY. The influence of thermal annealing typical for device fabrication on the Si capping layer is analysed. Si oxide formation is observed independently of annealing, with a thicker oxide layer forming in the annealed sample and an additional shift in binding energies. Additional oxidation states are found close to the Si/Al_2O_3 interface. Although the entire Si layer is thought to be oxidized, no Ge oxide was detected. This study improves our understanding of the influence of qubit preparation processes.

QI 14.24 Wed 18:00 P4

Industrially fabricated and isotopically enriched Si/SiGe Quantum Dots for coherent spin qubit control — •Dominic Barthlott[1], Viktor Adam[1], Daniel Sitter[1], Daniel Schroller[1], Clement Godfrin[2], and Wolfgang Wernsdorfer[1] — [1]Physikalisches Institut (PHI), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]Interuniversity Microelectronics Centre (imec), Leuven, Belgium

Spin qubits represent a promising quantum-computing platform due to their combination of long coherence times and compatibility with established, industry-supported semiconductor fabrication techniques. Enrichment with ^{28}Si isotopes can increase the coherence time of the qubit by reducing the amount of naturally occurring ^{29}Si which has a non-zero nuclear spin. Hence, we are investigating this effect by comparing enriched to non-enriched samples fabricated using industry-level processes. The devices consist of two quantum dots and one single-electron transistor (SET) which is used for charge sensing, thereby detecting electron tunnel events in the quantum dots. By adjusting the gate voltages, the system can be tuned to its ground-state charge configuration, allowing individual electrons to be loaded into each quantum dot. After this initialization, two individual qubits are defined and can be coherently driven. Their performance is concluded by carrying out standard benchmark protocols, including T_1 relaxation measurements or Ramsey and Hahn-echo sequences for T_2 determination.

QI 14.25 Wed 18:00 P4

Induced quantum dot microscopy of germanium and graphene quantum devices — •Patrick Raif[1,2], Aurèle Kamber[1], Luca Forrer[1,2], Christian Olsen[1], Martino Poggio[1,2], Andrea Hofmann[1,2], and Floris Braakman[1,2] — [1]Department of Physics, Basel, Switzerland — [2]Swiss Nanoscience Institute, Basel, Switzerland

Quantum dots are fundamental building blocks for semiconductor-based qubits [1], which are a promising platform for quantum computation due to the high compatibility with currently existing manufacturing technology and the potential for scaling up. In recent years, planar Ge/SiGe heterostructures have been established as a leading material for such devices, in particular for the implementation of spin qubits [2].

However, even the highest quality qubit devices show significant variations of important parameters like coherence times, pinch-off voltages, tunnel barrier heights, Landé g-factors, spin-orbit lengths, and valley splittings. These variations represent a serious obstacle for scaling up as they necessitate tuning of the individual quantum dots.

To map out the spatial variations we will apply newly developed scanning probe microscopy techniques using cantilevers that are patterned with multiple gates via electron-beam lithography [3] by inducing quantum dots in a quantum well underneath the cantilever.

[1] G. Burkard, et al., *Rev. Mod. Phys.* **95**, 025003 (2023). [2] G. Scappucci, et al., *Nat. Rev. Mat.* **6**, 926-943 (2021). [3] L. Forrer, et al., *AIP Advances* **13**, 035208 (2023).

QI 14.26 Wed 18:00 P4

Exploration of exotic dielectric barrier materials for quantum computing — •Leqi Zhou[1], Thomas J. Smart[1], Christine Falter[1,2], Josua Thieme[1,2], Joscha Domnick[1], Benjamin Bennemann[1,2], Detlev Grützmacher[1], Peter Schüffelgen[1], and Alexander Pawlis[1,2] — [1]Peter Gruenberg Institute, Forschungszentrum Juelich GmbH, Juelich, Germany — [2]JARA-Fundamentals of Future Information Technology, Juelich-Aachen Research Alliance, Aachen, Germany

A majority of the modern research performed on superconducting quantum systems uses Al2O3 as the dielectric barrier material of interest. However, there has been renewed interest in alternatives to Al2O3 as a barrier material, due to the formation of two-level systems (TLSs) which can impede device performance. Within this work, we explore the deposition of alternative dielectric materials, such as AlN and TiO2. These films, grown via different epitaxy techniques are then electrically characterized to determine their resistive and capacitive properties. By optimizing the growth processes, based on these electrical measurements, we aim to implement these alternative dielectric materials into Josephson Junctions to test their suitability for future quantum computing systems.

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Low-overhead Liouvillian Learning of Superconducting Qubit Arrays via Simultaneous Weak Measurements — •Markus Sifft, Armin Ghorbanietemad, and Daniel Hägele — Ruhr University Bochum, Faculty of Physics and Astronomy, Germany

Building on quantum polyspectra for higher-order noise analysis [1,2], we present a low-overhead protocol to reconstruct the Liouvillian of an open system from continuous weak multi-detector measurements of qubits. From a parameterized Liouvillian and measurement operators, we use closed-form expressions for multi-channel polyspectra up to fourth order, which compactly encode coherent dynamics and dissipation. Fitting theory to measured spectra allows us to extract key Hamiltonian and dissipative parameters of superconducting-qubit processors, including qubit frequencies, coherent couplings, crosstalk, drive leakage, and effective temperatures, even with background noise and in the ultra-weak measurement regime. A Fisher-information-based figure of merit quantifies identifiability and optimizes drive frequencies, amplitudes, measurement strengths, and operating temperature. The framework scales to many detectors and qubits, yields error bars and measurement-time estimates, and, compared to standard pulsed characterization, enables spectroscopy-style characterization from a single continuous experiment. All ingredients are implemented in our open-source QuantumCatch [3] and SignalSnap [4] libraries. [1] Hägele, Phys. Rev. B 98, 205143 (2018) [2] M. Sifft et al., arXiv:2505.01231 (2025) [3] github.com/markussifft/quantumcatch [4] github.com/ArminGEtemad/SignalSnap-PyTorch

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Making entanglement witnesses robust to measurement errors — •Elisa Monchietti and Otfried Gühne — Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany

In recent years, a variety of methods have been developed to characterise quantum entanglement, among which entanglement witnesses are one of the most widely studied tools. A major limitation of these operators, however, is their high sensitivity to measurement imperfections, which can lead to false positives in the detection of entangled states. In realistic experimental scenarios, even with advanced error-mitigation techniques, measurement errors arising from device imperfections and external noise cannot be completely eliminated. In this work, we aim to characterise quantum correlations in a more realistic framework by explicitly accounting for imprecise measurements. To this end, we investigate correction terms that can be incorporated to compensate for the effects of measurement misalignment and device imperfections. In particular, we study the existence and construction of entanglement witnesses for multiqubit systems that remain robust against misalignment errors.