Book of abstracts

Poster session of the ASC school 2025 "Quantum Computing – Status and Prospects"

October 6

1. **Growing the distance of fermion-to-qubit encodings**

   Manuel Algaba (IQM Quantum Computers & Autonomous University of Madrid)

   Fermion-to-qubit encodings are widely used in fermionic simulation but encodings with distances beyond d=1 tend to be very expensive in terms of qubit-fermion ratios, operator weights and qubit connectivities, not to mention that their distance is fixed. In this work, we introduce the Ladder Encoding, a fermion-to-qubit mapping of scalable distance with optimal weight operators when considering 1D systems, that is built from the surface code, so it can be embedded into a square grid lattice. We also extend it to a local 2D encoding and use the developed concepts to find an extra spinful encoding with desirable properties. Since the strategy for growing the distance is general and based on topological error correction codes, it is shown to apply to other encodings such as the ones by Derby-Klassen and Verstraete-Cirac and we also exemplify it works for a different embedding, using the 6.6.6 triangular color code. Finally, we analytically and numerically study the effect of noise when the distance of the used encoding is grown.

2. **Probing quantum error correction with tensor network simulations**

   Francesco Pio Barone (University of Padova)

   A quantum error correction code is assessed over its ability to correct errors in noisy quantum circuits. This task requires extensive simulations of faulty quantum circuits, which are often made tractable by considering Clifford circuits and stochastic Pauli noise models, as they are compatible with efficient classical simulation techniques. We exploit Quantum Matcha TEA - a quantum circuit simulation library based on tensor networks - to simulate quantum error correction circuits up to hundreds physical and multiple logical qubits. This approach enables the exploration of the interplay between entanglement, noise, and error correction performance. While Clifford-based methods remain more efficient for simulating Pauli noise, tensor networks provide a powerful tool for studying QEC thresholds and their dependence on general noise models. Additionally, Quantum Matcha TEA facilitates (i) entanglement characterization throughout an error correction protocol, including mixed-state entanglement, and (ii) the implementation of more realistic noise models, such as non-unitary error channels represented by Kraus operators. We show how this tool can be applied to estimate thresholds via sampling, but also through coherent information approaches.

3. **Quantum Error Mitigation for Variational Quantum Eigensolver**

   Hamza Benkadour (University of Constantine 1)

   Noisy intermediate-scale quantum (NISQ) devices present a major challenge for reliable quantum computation, especially in variational algorithms such as the Variational Quantum Eigensolver (VQE). In this work, we investigate Quantum Error Mitigation (QEM) techniques such as Zero Noise Extrapolation (ZNE), Readout Error Mitigation (REM), and dynamical decoupling to improve the performance of VQE. Focusing on molecular ground state estimation, we benchmark the effectiveness of these techniques under simulated noise models using qiskit. Our results highlight the effect of QEM techniques to reduce bias in expectation values and improve algorithm stability without full quantum error correction.

4. **Phase-Sensitive Measurements on a Fermi-Hubbard Quantum Processor**

   Alberto Cavallar (LMU Munich)

   Fermionic quantum processors are a promising platform for quantum simulation of correlated fermionic matter. In this work, we study a hardware-efficient protocol for measuring complex expectation values of the time-evolution operator, commonly referred to as Loschmidt echoes, with fermions in an optical superlattice. We analyze the algorithm for the Fermi–Hubbard model at half-filling as well as at finite doping. The method relies on global quench dynamics and short imaginary time evolution, the latter being realized by architecture-tailored pulse sequences starting from a product state of plaquettes. Our numerical results show that complex Loschmidt echoes can be efficiently obtained for large many-body states over a broad spectral range. This allows one to measure spectral properties of the Fermi–Hubbard model, such as the local density of states, and paves the way for the study of finite-temperature properties in current fermionic quantum simulators.

5. **QuaNTUM: A Modular Quantum Communication Testbed for Scalable Fiber and Satellite Integration**

   Julien Chénedé (Technical University of Munich)

   Secure communication is essential for modern society, yet classical encryption faces existential threats from advancing computational power. Quantum communication provides a fundamentally secure alternative by leveraging physical laws to protect data. We present QuaNTUM (Quantum Network at TUM), a modular, extensible testbed for scalable quantum communication across fiber-based campus networks and satellite-ground links. As an open-access platform, it supports experimental protocols, device benchmarking, and hybrid network integration, combining terrestrial fiber infrastructure with early deployments of solid-state quantum emitters in small satellites, bridging terrestrial and free-space channels. The terrestrial network connects research institutes via single-mode fibers in a star topology, featuring polarization-maintaining components, multiplexers, and time-synchronized analysis modules. A central switching hub enables dynamic routing, while active polarization control and real-time feedback ensure low-error, high-fidelity quantum key distribution (QKD) and entanglement distribution. A core innovation is QuaNTUM's use of deterministic single-photon sources, such as hBN defects or erbium atoms, currently being deployed in orbit, marking one of the first demonstrations of a solid-state quantum emitter in space. By unifying fiber and free-space links with scalable hardware, this testbed provides a solution for future hybrid quantum networks, supporting both near-term research and the long-term vision of a global quantum internet.

6. **On the Theory and Functionality of Local Disentangling Algorithms**

   Ludvík Cigna (LMU)

   Controlling entanglement is pivotal for the advancement of quantum technologies. In this context, disentangling algorithms have attracted significant attention due to their potential to address challenges in quantum state preparation, compression, complexity estimation, and quantum control. In our work, we introduce a unified and mathematically rigorous framework for disentangling based on local measurements, which is particularly suitable for current NISQ devices. This framework provides a generalization to multi-qubit disentangling and offers practical speed-ups compared to previous heuristic approaches, building on a recent solution to the relaxed quantum marginal problem. We further analyze the convergence behavior and the evolving structure of states during the algorithm, starting from Haar-random states.

7. **The Bilayer Kagome Lattices for Nanoelectronic Devices**

   Taylan Görkan (Bilkent University, UNAM-National Nanotechnology Research Center)

   Topologically nontrivial flat bands (FBs) and Dirac nodal lines have recently drawn significant attention in condensed matter physics, yet a transition between these two distinct states has remained unexplored. Here, we employ a tight-binding (TB) approach to uncover a novel transition mechanism from FBs to Dirac nodal lines, driven by the interplay among destructive quantum interference (DQI), C3 symmetry, and spatial inversion symmetry in AB-stacked bilayer kagome lattices. Our results reveal that strong interlayer interactions relative to in-plane hopping amplitudes enable DQI to dominate, resulting in FBs associated with compact localized states. Conversely, weaker interlayer interactions enhance the role of C3 symmetry and inversion symmetry, transforming FBs into robust Dirac nodal lines. By systematically tuning interlayer hopping parameters, we demonstrate the controlled evolution between flat bands, type-II and type-III Dirac cones, and spin-1 Dirac cones. Furthermore, we predict that metal oxides and chalcogenides crystallizing in AB-stacked bilayer breathing kagome lattices are ideal candidates for experimentally realizing this transition mechanism, showcasing diverse electronic states accessible via strain engineering. Our findings offer fundamental insights into the rich physics of kagome lattice systems and pave the way toward the rational design of novel quantum materials.

8. **Programmable Arrays of Rydberg Ytterbium Atoms for Quantum Computing**

   Krishan Joshi (University of Naples and CNR-INO Florence)

   Alkaline earth-like atoms are proving to be promising candidates for next-generation fault-tolerant quantum computing platforms. We are currently developing an experimental setup for the realization of a quantum computational platform based on fermionic 171Yb atoms, trapped in optical tweezers with reconfigurable geometries. In this system, the electronic states of fermionic 171Yb are employed as stable, long-lived qubit states, while Rydberg excitations facilitate multiqubit operations. 171Yb also has the advantage of the metastable clock state qubit for extended coherence times, magic wavelength tweezers for the clock state, and employs both broad and narrow optical transitions for cooling and manipulating internal atomic states within the tweezers. The ground and metastable state qubits can be utilized as ancilla and data qubits for quantum error correction codes. A high magnetic field is used to support high-power excitations and perform large Rabi oscillations, allowing for rapid entangling gate operations.

9. **Ground state of bilayer graphene quantum dots**

   Konstantinos Kontogeorgiou (RWTH Aachen University)

   Quantum dots have attracted significant interest in recent years, particularly for their potential applications in quantum computing as qubits. In this work, we investigate the ground state energy of a quantum dot in bilayer graphene. The system's Hamiltonian is composed of a term linear in momentum and another quadratic in momentum. We analyze the contribution of each to the total ground state energy, and we discuss in which limits each term is relevant. Additionally, we examine how the ground state energy is modified in the presence of uniform electric and magnetic fields.

10. **Riemannian quantum circuit optimization based on matrix product operators**

    Isabel Nha Minh Le (Technical University of Munich)

    We significantly enhance the simulation accuracy of initial Trotter circuits for Hamiltonian simulation of quantum systems by integrating first-order Riemannian optimization with tensor network methods. Unlike previous approaches, our method imposes no symmetry assumptions, such as translational invariance, on the quantum systems. This technique is scalable to large systems through the use of a matrix product operator representation of the reference time evolution propagator. Our optimization routine is applied to various spin chains and fermionic systems, with a particular focus on one-dimensional systems described by the transverse-field Ising Hamiltonian, the Heisenberg Hamiltonian, and the spinful Fermi-Hubbard Hamiltonian. In these cases, our approach achieves a relative error improvement of up to four orders of magnitude. Furthermore, we demonstrate the versatility of our method by applying it to molecular systems, specifically lithium hydride, achieving an error improvement of up to eight orders of magnitude. This proof of concept highlights the potential of our approach for broader applications in quantum simulations.

11. **Highly entangled stationary states in open quantum systems**

    Yahui Li (Technical University of Munich)

    We find that the presence of strong non-Abelian symmetries can lead to highly entangled stationary states even for unital quantum channels. We derive exact expressions for the bipartite logarithmic negativity, Rényi negativities, and operator space entanglement for stationary states restricted to one symmetric subspace, with focus on the trivial subspace. As Abelian examples, we show that strong $U(1)$ symmetries and classical fragmentation lead to separable stationary states in any symmetric subspace. In contrast, for non-Abelian $SU(N)$ symmetries, both logarithmic and Rényi negativities scale logarithmically with system size. Finally, we prove that the logarithmic negativity exhibits a volume-law scaling for certain quantum fragmented models. Our analytic derivations apply to universal enveloping algebra of a Lie algebra, the Read-Saleur commutants for quantum fragmentation, as well as finite groups and quantum groups.

12. **Matrix Product Operator: Symmetries, Renormalization Fixed Points and Parent Lindbladian**

    Yuhan Liu (Max Planck Institute of Quantum Optics)

    Classifying quantum phases of matter in mixed states is a fundamental yet open problem. Tensor network methods offer a powerful framework, where renormalization fixed points (RFPs) of matrix product density operators (MPDOs) are expected to be representatives of one-dimensional mixed-state phases. In our work, we establish a general sufficient condition under which a non-counital C^*-pre-bialgebra generates an RFP state. We also analytically constructing parent Lindbladians for MPDO RFPs. These Lindbladians are local, frustration-free, and exhibit minimal steady-state degeneracy. Our results reveal a new algebraic mechanism for constructing fixed-point MPDOs, and a physical process to prepare such states as steady states of the Markovian evolution.

13. **Quantum Technology Platform Beyond 1000 Atomic Qubits for Quantum Simulation, Computation, Metrology, and Sensing**

    Marcel Mittenbühler (TU Darmstadt - Atoms-Photons-Quanta)

    Quantum arrays of neutral atoms in regular optical potentials of multi-site tweezer networks and optical lattices foster numerous applications in quantum optics, metrology, and information science, where comprehensive laser control enables the realization of textbook examples of quantum models. We create microlens-based tweezer arrays that pave the way to a scalable platform for Rydberg-mediated quantum physics. Specific to our approach, microlens arrays not only create a single focal plane but also give multiple Talbot layers suitable for trapping and manipulating individual atoms. Thus, they allow scaling the number of available qubits without requiring additional laser power. Multiple Talbot layers can be addressed, scaling the system size to 10,000 usable sites. Beyond the main targeted application in quantum simulation and computation, a practical use case of tweezer arrays in quantum sensing has been demonstrated by utilizing an assembled 2D array of atoms as a magnetic field detector with parallelized operation of 270 single-atom sensor pixels with 7 micrometer spacing and sub-micrometer spatial resolution. For future advancements of this platform, scaled and parallelized control techniques are key. A main limitation is given by the transport of atoms within a tweezer array. Optical tweezers generated by two crossed AODs have become the standard method to generate movable tweezers with their position depending on the radio frequency supplied. To overcome the limitation of single tweezers, it is possible to provide a multi-tone signal, generating multiple tweezers. Although conceptually simple, such an approach presents numerous challenges for the RF signal generation and for the control setup to coordinate multiple parallelized tweezers.

14. **Efficient LCU block encodings through Dicke states preparation**

    Martina Nibbi (Technical University of Munich)

    As algorithmic tools exemplified by the Quantum Singular Value Transformation (QSVT) continue to emerge as a unifying framework for diverse quantum speedups, the efficient construction of block encodings, their fundamental input model, becomes increasingly crucial. However, devising explicit block encoding circuits remains a well-recognized and challenging problem. One of the most widely studied and versatile approaches to block encoding is the Linear Combination of Unitaries (LCU). Despite its generality, the practical use of LCU is often limited by significant gate overhead. We introduce a compact LCU formulation, dubbed Fast One-Qubit-Controlled Select LCU (FOQCS-LCU), which leverages the check matrix formalism to implement a constant-depth SELECT oracle using a linear number of singly controlled Pauli gates and ancillae. We demonstrate that, by exploiting the structure of the problem, the cost of the state preparation oracle can also be substantially reduced. We accomplish so by designing a parametrized family of efficient Dicke state preparation routines. We construct explicit block encoding circuits for representative spin models such as the Heisenberg and spin glass Hamiltonians and provide detailed, non-asymptotic gate counts. Our numerical benchmarks validate the efficiency of the FOQCS-LCU approach, illustrating an order-of-magnitude improvement in CNOT count over conventional LCU. This framework opens the door to efficient block encodings of a broad class of structured matrices beyond those explored here.

15. **BenchQC: First results from application driven benchmarking**

    Johannes Oberreuter (Machine Learning Reply GmbH)

We will present our contribution to QUARK, an application driven benchmarking framework of quantum computers and algorithms. We will outline some of the use cases which have been implemented, explain the chosen metrics and present results obtained so far from scaling analysis.

16. **Nuances of Data-Reuploading Schemes for Quantum Machine Learning**

    Felix Paul (German Aerospace Center (DLR))

    Since the advent of Quantum Machine Learning (QML), the expressivity and generalizability of variational QML-models has been an extensive research area. In this context, formulating the objective function as a truncated Fourier series in the input features has given many insights into the underlying structure of such a model. We empirically investigate different approaches for the circuit design, in order to manipulate the spectrum as well as the coefficients of the Fourier series. We evaluate the performance of the designs by comparing the training behaviour under various conditions and give advice on the applicability of theoretical results in a realistic setting.

17. **Solving systems of linear equations using the HHL algorithm in Qrisp**

    Matic Petrič (Fraunhofer FOKUS)

    We present an efficient implementation of the Harrow-Hassidim-Lloyd (HHL) quantum algorithm using the Qrisp high-level programming abstractions and Catalyst's compilation capabilities. Qrisp's new compilation pipeline, based on the integration of the JAX machine learning framework, allows for real-time computations and repeat-until-success protocols used in many quantum algorithms (HHL, LCU, etc.). This enabled us to modularly implement the critical components of the HHL algorithm: encoding, Quantum Phase Estimation (QPE), and Hamiltonian simulation. Results from our benchmarks on 8x8 matrices align, with high fidelity, with those obtained classically, demonstrating the framework's potential for implementing complex algorithms efficiently. This work not only validates the practicality of Qrisp's abstractions but also builds upon the approach of implementing algorithms through the paradigm of QuantumVariables, QuantumTypes, and algorithmic primitives expressed as functions.

18. **Characterizing and modeling crosstalk in quantum computers**

    Teemu Pihkakoski (University of Oulu)

    Crosstalk errors in quantum computers occur when operations performed on one qubit unintentionally influence others [1]. One source of these errors is residual coupling between qubits, where qubits meant to operate independently are instead influencing each other. A second source is electromagnetic interference from control lines when performing operations to the qubits. These errors degrade the accuracy of quantum algorithms, and they also introduce security vulnerabilities in multiuser environments, where multiple users can access different parts of the same quantum computer at the same time [2]. In this work, we characterize crosstalk in quantum computers using a method called randomized benchmarking to extract the strength of crosstalk errors in available quantum computers [3]. Using this method, we measure the strength of crosstalk errors between different distances of qubits in the quantum computer [4]. We also seek to incorporate these crosstalk errors into error models, which can be used in quantum simulators. In our work, we also aim to study how methods such as error mitigation and error correction could be used to reduce the effects of crosstalk errors, making quantum computers more reliable and secure. [1] Sarovar, M., Proctor, T., Rudinger, K., Young, K., Nielsen, E., & Blume-Kohout, R. (2020). Detecting crosstalk errors in quantum information processors. Quantum, 4, 321. https://doi.org/10.22331/q-2020-09-11-321 [2] Ash-Saki, A., Alam, M., & Ghosh, S. (2020). Analysis of crosstalk in NISQ devices and security implications in multi-programming regime. Proceedings of the ACM/IEEE International Symposium on Low Power Electronics and Design, 25–30. https://doi.org/10.1145/3370748.3406570 [3] Magesan, E., Gambetta, J. M., & Emerson, J. (2011). Robust randomized benchmarking of quantum processes. Physical Review Letters, 106(18), 180504. https://doi.org/10.1103/PhysRevLett.106.180504 [4] Ketterer, A., & Wellens, T. (2023). Characterizing crosstalk of superconducting transmon processors. Physical Review Applied, 20(3), 034065. https://doi.org/10.1103/PhysRevApplied.20.034065

19. **Learning density functionals from noisy quantum data**

    Eric Prehn (DLR (Quantum Computing Initiative (QCI)))

    The search for useful applications of noisy intermediate-scale quantum (NISQ) devices in quantum simulation has been hindered by their intrinsic noise and the high costs associated with achieving high accuracy. A promising approach to finding utility despite these challenges involves using quantum devices to generate training data for classical machine learning (ML) models. In this study, we explore the use of noisy data generated by quantum algorithms in training an ML model to learn a density functional for the Fermi–Hubbard model. We benchmark various ML models against exact solutions, demonstrating that a neural-network ML model can successfully generalize from small datasets subject to noise typical of NISQ algorithms. The learning procedure can effectively filter out unbiased sampling noise, resulting in a trained model that outperforms any individual training data point. Conversely, when trained on data with expressibility and optimization error typical of the variational quantum eigensolver, the model replicates the biases present in the training data. The trained models can be applied to solving new problem instances in a Kohn–Sham-like density optimization scheme, benefiting from automatic differentiability and achieving reasonably accurate solutions on most problem instances. Our findings suggest a promising pathway for leveraging NISQ devices in practical quantum simulations, highlighting both the potential benefits and the challenges that need to be addressed for successful integration of quantum computing and ML techniques.

20. **Quantum Simulation of Magnetic Resonance Experiments in Material Sciences**

    Armin Römer (Forschungszentrum Jülich)

    We present current progress in simulating magnetic radio-frequency pulses for nuclear magnetic resonance (NMR) experiments on quantum devices. Pulse simulations can be used to tailor NMR experiments using the quantum optimal control (QOC) method, enabling highly robust yet selective NMR experiments. As a result, QOC-NMR facilitates accurate measurements of heterogeneous systems, including at interfaces or within membranes, pushing the NMR method beyond its standard applications into new fields such as electrochemistry or catalysis. QOC pulses optimized on classical hardware have already led to impressive results in NMR and therefore provide a useful benchmark for quantum simulations on noisy intermediate-scale quantum (NISQ) devices. Furthermore, quantum hardware has the potential to overcome some of the challenges faced by classical QOC workflows. For example, QOC algorithms require repeated full simulations of the relevant quantum dynamics. Hence, computational complexity can scale exponentially at worst when dealing with strongly coupled spin systems, such as aromatic compounds in low-fields, let alone polymers. Also, engineering robust magnetic resonance experiments that perform well for heterogeneous systems require large-scale parallel computations over multiple ranges of experimental parameters. By exploring the capabilities of quantum devices, we hope to find ways to circumvent QOC workflow bottlenecks in classical computing.

21. **Error model drift detection with Probabilistic Error Cancellation**

    Francesc Sabater (TUM/BMW Group)

    The error model affecting individual gates can generally be characterized using gate tomography. However, it is crucial to detect and certify drifts in the error parameters during the execution of a full quantum computation. In this work, we propose a certification protocol that combines Probabilistic Error Cancellation (PEC) with Direct Fidelity Estimation (DFE) to detect such drifts and certify a given error model in realistic noisy quantum computations. The protocol estimates the fidelity between the ideal quantum state and the effectively mitigated quantum state, which may become non-physical (non-CP). We adapt known results on the sampling complexity of DFE to this mitigated setting. Furthermore, we show that overestimating the error model can lead to a non-CP mitigated state, causing the fidelity to exceed one. This behavior enables not only the detection of parameter drifts but also the identification of their direction—whether the model is over- or underestimated.

22. **Hardware-efficient quantum phase estimation via local control**

    Benjamin Schiffer (Max Planck Institute of Quantum Optics)

    Quantum phase estimation plays a central role in quantum simulation as it enables the study of spectral properties of many-body quantum systems. Most variants of the phase estimation algorithm require the application of the global unitary evolution conditioned on the state of one or more auxiliary qubits, posing a significant challenge for current quantum devices. In this work, we present an approach to quantum phase estimation that uses only locally controlled operations, resulting in a significantly reduced circuit depth. At the heart of our approach are efficient routines to measure the complex phase of the expectation value of the time-evolution operator, the so-called Loschmidt echo, for both circuit dynamics and Hamiltonian dynamics. By tracking changes in the phase during the dynamics, the routines trade circuit depth for an increased sampling cost and classical postprocessing. Our approach does not rely on reference states and is applicable to any efficiently preparable state, regardless of its correlations. We provide a comprehensive analysis of the sample complexity and illustrate the results with numerical simulations. Our methods offer a practical pathway for measuring spectral properties in large many-body quantum systems using current quantum devices.

23. **A Hybrid Learning Agent Appraoch For Solving The Flight Trajectory Optimization**

    Marcel Schindler (Deutsches Zentrum für Luft- und Raumfahrt e.V.)

    It is believed that combinatorial optimization is to be among the first applications where quantum computers can demonstrate a practical advantage over classical systems. One such problem is the Flight Trajectory Optimization, which aims to find the optimal path between two airports for an airplane. Due to non-local constraints of the flight path, the problem is part of complexity class NP-Hard and becomes difficult to solve for classical algorithms. To address this, we employ a Reinforcement Learning algorithm in which the learning process of an agent is sped up by using a quantum communication channel. Our results show that the initial learning rate can be significantly enhanced, resulting in a faster learning process for the agent.

24. **Linearized Lindblad equation - A tool for non-unitary quantum dynamics**

    Jonathan Schluck (RWTH Aachen)

    In Quantum mechanics, a system's dynamics are originally described by the Schroedinger equation. This leads to unitary time evolution of the state vector. One major problem of this description is, that it demands total isolation of the considered system. No interactions with an environment can be represented in this formulation. The Lindblad master equation allows us to generalize the Schroedinger equation by including interaction terms, such like photon loss. Thus the dynamics become non-unitary. Especially in driven systems, it is important to include dissipation, since we would run into instabilities otherwise. In its canonical form, the Lindblad equation is a non-linear differential equation of a system's density matrix. We present a way to linearize this equation by redefining our understanding of operators and state vectors. We also discuss, which further statements can be derived from this formalism.

25. **Solving the Product Breakdown Structure Problem with constrained QAOA**

    Niklas Steinmann (Fraunhofer FOKUS)

    Constrained optimization problems, where not all possible variable assignments are feasible solutions, comprise numerous practically relevant optimization problems such as the Traveling Salesman Problem (TSP), or portfolio optimization. Established methods such as quantum annealing or vanilla QAOA usually transform the problem statement into a QUBO (Quadratic Unconstrained Binary Optimization) form, where the constraints are enforced by auxiliary terms in the QUBO objective. Consequently, such approaches fail to utilize the additional structure provided by the constraints. In this paper, we present a method for solving the industry relevant Product Breakdown Structure problem. Our solution is based on constrained QAOA, which by construction never explores the part of the Hilbert space that represents solutions forbidden by the problem constraints. The size of the search space is thereby reduced significantly. We experimentally show that this approach has not only a very favorable scaling behavior, but also appears to suppress the negative effects of Barren Plateaus.

26. **Matrix Product Quantum Channels (MPQC)**

    Giorgio Stucchi (MPQ Theory)

    We construct explicit examples to show inequivalence of non translationally invariant (NTI) MPQC and quantum channels with a local stinespring dilation (LSD). We find a standard form for matrix product isometries (MPI) and show they can be represented as depth-two quantum circuits of isometry gates. We show that allowing for a size independent normalization factor different than one yields the possibility of creating long range correlations.

27. **Numerical Verification of Experimental Local Current Measurements in Bosonic Flux Ladders**

Yudong Sun (LMU, ASC)

Topological quantum systems are an attractive platform for fault-tolerant quantum computing. Flux ladders implemented in ultracold atomic quantum gas microscopes present themselves as a promising candidate for such topological quantum system. Yet, characterising prepared topologically states requires the measurement of local current observables that are experimentally not directly accessible. In this project, we rigorously investigate the dynamic current measurement protocol proposed by Kessler and Marquardt (2014) through analytical derivations and numerical simulations with exact diagonalisation (ED), assessing the impact of the employed approximations on measurement outcomes. We observe that non-bosonic statistics arising from finite-dimensional Hilbert spaces introduce systematic errors for ground states and thermal states, which are however subleading compared to the uncertainties arising from the parity-projected measurement.

28. **First Hitting Times on a Quantum Computer: Tracking vs. Local Monitoring, Topological Effects, and Dark States**

    Sabine Tornow (University of the Bundeswehr)

    We investigate a quantum walk on a ring represented by a directed triangle graph with complex edge weights and monitored at a constant rate until the quantum walker is detected. To this end, the first hitting time statistics are recorded using unitary dynamics interspersed stroboscopically by measurements, which are implemented on IBM quantum computers with a midcircuit readout option. Unlike classical hitting times, the statistical aspect of the problem depends on the way we construct the measured path, an effect that we quantify experimentally. First, we experimentally verify the theoretical prediction that the mean return time to a target state is quantized, with abrupt discontinuities found for specific sampling times and other control parameters, which has a well-known topological interpretation. Second, depending on the initial state, system parameters, and measurement protocol, the detection probability can be less than one or even zero, which is related to dark-state physics. Both return-time quantization and the appearance of the dark states are related to degeneracies in the eigenvalues of the unitary time evolution operator. We conclude that, for the IBM quantum computer under study, the first hitting times of monitored quantum walks are resilient to noise. However, a finite number of measurements leads to broadening effects, which modify the topological quantization and chiral effects of the asymptotic theory with an infinite number of measurements.

29. **Erbium dopants for quantum networks**

    Paul-Valentin von Massow (Quantum Networks TUM)

    This poster summarises the main research themes of the Quantum Networks group at TUM, focusing on erbium-doped silicon as a scalable platform for quantum networks. We highlight why erbium in silicon is promising, combining telecom-band optical transitions with mature semiconductor technology. The poster covers recent results on the spectroscopy of erbium centres in silicon, their electron spin properties in silicon, and the potential of erbium nuclear spins in YSO crystals for quantum memory. These advances support the development of scalable, fibre-compatible quantum network nodes.

30. **Developing Efficient and Scalable Ansatz for Quantum Chemistry and Material Science**

    Kaan Yurtseven (University of Oulu)

    NISQ (Noisy Intermediate-Scale Quantum) devices offer the potential for scalable quantum computing, with quantum chemistry simulation as a key application. However, simulating large molecules remains challenging due to the exponential growth of computational costs. Variational Quantum Algorithms (VQAs), a hybrid quantum-classical framework, are among the most promising methods for addressing these challenges for near term quantum computing. Despite their success, optimization issues like Barren Plateaus and the dependence on problem-specific ansatz design remain open problems. We explore the performance of Hamiltonian Variational Ansatz(HVA), which has recently been shown to have reasonable convergence under some strict assumptions. We tried to ease these strong assumptions. Then, we explore the compression and factorization techniques such as Compressed Factorized Hamiltonian(CDF) and Explicit Factorized Hamiltonian(XDF) and tried to reduce the cost of simulation and decreasing the depth of the ansatz in HVA. Our preliminary results show a significant improvements compared to standard hardware efficient and chemically inspired ansatzes.

31. **Hybrid Quantum Reinforcement Learning for Sequence Alignment: Action-Sequence Policies and NISQ-Compatible Design**

    Annette Zapf (DLR)

    Pairwise sequence alignment is central in bioinformatics for analyzing DNA, RNA, and proteins, revealing similarities that inform evolutionary relationships, gene or protein functions, and disease mechanisms. Classical dynamic programming guarantees optimal alignments but scales poorly, while heuristics reduce runtime at the cost of optimality and still require high resources. Quantum algorithms exploit superposition and entanglement to accelerate optimization or find exact solutions faster. We present a hybrid quantum reinforcement learning (RL) agent based on (Hamann & Wölk, 2022), optimized for NISQ hardware. The agent learns a policy mapping states to action sequences from feedback of an environment. Using a Grover-like subroutine, it evaluates all sequences in parallel, reinforcing those leading to a solution, which reduces environment interactions and achieving quadratic speedup over classical RL. To enable execution on current hardware, we introduce a novel Parameterized Quantum Policy embedding entire action sequences, combined with a simplified Grover routine using a black-box oracle. This reduces resource demands but requires prior knowledge and retraining per alignment, limiting generalization. We also outline design ideas for a more general Grover oracle and circuit with broader generalization, which, while not NISQ-compatible, suggest a promising direction for future work.

32. **Adiabatic echo protocols: robust preparation of quantum many-body states**

    Zhongda Zeng (University of Innsbruck & IQOQI)

    Entangled many-body states are a key resource for quantum technologies. Yet their preparation through analog control of interacting quantum systems is often hindered by experimental imperfections. Here, we introduce the adiabatic echo protocol, a general approach to state preparation designed to suppress the effect of static perturbations. We provide an analytical understanding of its robustness in terms of dynamically engineered destructive interference. By applying quantum optimal control methods, we demonstrate that such a protocol emerges naturally in a variety of settings, without requiring assumptions on the form of the control fields. Examples include Greenberger-Horne-Zeilinger state preparation in Ising spin chains and two-dimensional Rydberg atom arrays, as well as the generation of quantum spin liquid states in frustrated Rydberg lattices. Our results highlight the broad applicability of this protocol, providing a practical framework for reliable many-body state preparation in present-day quantum platforms.