Book of Abstracts - Posters

8th International Conference for Young Quantum Information Scientists (YQIS25)

Organizing Committee

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Contents

Poster Session I, Tuesday

1 - Quantum Generative Adversaria Networks: Improving Dynamics Simulation with an Ancilla Qubit

Guillermo Abad López – GIQ, UAB

Quantum Generative Adversarial Networks (QGANs) offer a promising way at learning the time evolution of complex target Hamiltonians using significantly fewer gates than traditional methods. However, standard QGAN architectures commonly suffer from unstable convergence and learning plateaus in the loss landscape.

We propose augmenting the generator with an ancilla qubit, enabling training to progress when the model becomes trapped in flat regions of the loss landscape. In this work, we investigate the effect of incorporating an ancilla under various connectivity topologies and at different stages of training, in order to aid the generator in escaping plateaus.

Results show that the ancilla helps overcome plateaus when the ancilla's connectivity links distant regions of the ansatz. Notably, the overall fidelity improves when the ancilla is introduced midway through the training.

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2 - Optimal cloning of two unitary channels

Ardra Ajitha Vijayan – RCQI, Institute of Physics, Slovak Academy of Sciences

We investigate the optimal perfect probabilistic cloning of unitary channels from a single use to two copies in qubit systems. Considering the case where the unitary is drawn from a set of two with equal prior probabilities, we derive upper and lower bounds on the success probability of any cloning strategy. When plotted against the angular separation between the unitaries, the bounds coincide for $[0, \pi/4]$, identifying a measure-and-prepare protocol as optimal in this regime. For $[\pi/4, \pi/2]$, the bounds diverge, and numerical optimization shows that the optimal success probability falls strictly below the measure-and-prepare threshold, indicating the necessity of more sophisticated strategies.

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3 - Efficient Quantum Communication with Imperfect Entanglement

Mir Alimuddin – ICFO - The Institute of Photonic Sciences

Transmitting unknown quantum states is essential for distributed quantum information. Quantum teleportation accomplishes this with prior maximal entanglement, but in realistic settings, noise in entangled states limits performance. In long-range setups, quantum repeaters divide communication into segments, yet noise in any segment degrades fidelity. Conventional wisdom uses maximally entangled states and measurements in noiseless segments to recover optimal fidelity. We introduce a protocol for certain noisy states that matches the standard protocol's fidelity while using less entanglement. Even when the end-to-end state becomes noisier, our method preserves optimal teleportation fidelity, enabling more resource-efficient quantum repeater networks.

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4 - Two-Time Weak-Measurement Protocol for Ergotropy Protection in Open Quantum Batteries

André Hernandes Alves Malavazi – ICTQT - University of Gdańsk

In this work, we propose a protocol that employs selective weak measurements to protect quantum states from external influence and mitigate battery discharging. We establish thermodynamic constraints that allow this method to be implemented without disrupting the overall energy and ergotropy balance of the system, i.e., with no extra net recharging. Our findings demonstrate that appropriately chosen measurement intensity can reduce unwanted discharging effects, thereby preserving ergotropy and improving the stability of quantum batteries. We illustrate the protocol with single- and two-qubit systems and establish the generalization for N-cell batteries. Additionally, we explore how weak measurements influence the coherent and incoherent components of ergotropy, providing new insights into the practical application of quantum coherence in energy-storage technologies.

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5 - Photon-native Quantum Perceptrons and Neural Networks

Md Shadnan Azwad Khan – Quandela & Sorbonne University

Photonic quantum neural networks promise fast, low-energy learning but must reconcile linear optics with nonlinear activations. We present a spiking-inspired, photon-native architecture in the discrete-variable regime, in which reconfigurable interferometers implement learned linear maps and photon detection with classical feedforward yields a broad class of effective nonlinear responses. We first realize a photon-native quantum perceptron that implements decision boundaries beyond those of classical perceptrons. Building on this unit, we construct layered networks that pass a single classical scalar readout between units, the average detection rate, without requiring long-lived quantum memories. Across standard benchmarks, these networks train reliably and achieve accuracies comparable to classical fully connected feedforward neural networks of similar depth and parameter count.

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6 - Optimal variant of a noncontextuality inequality for experimental implementations

Gustavo Balvedi Pimentel – ICFO

Quantum contextuality results from the impossibility of explaining the probabilities of measurement outcomes in quantum systems using models that assume that observables have well-defined values prior to the measurement, and that these values do not depend on which other compatible measurements are performed simultaneously to the measurement. Contextuality has been widely studied experimentally, but real tests often break the no-disturbance assumption, motivating alternative frameworks that work under such conditions. This work extends Renou et al., who showed that variants of a Bell inequality, though equivalent under no-signaling, differ in experimental robustness. Their method uses the symmetry group of a Bell scenario to optimize such robustness. We generalize this approach to contextuality scenarios, employing group representation theory to optimize noncontextuality inequalities.

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7 - Error Mitigation via Phase Estimation in Superconducting Quantum Processors

Cristian Eliecer Bello Reyes – Universidad Nacional de Colombia

Quantum phase estimation (QPE) is a core algorithm for simulating chemical and solid state systems on fault tolerant quantum computers. For near term devices, recent variants reduce circuit depth and improve error resilience. However, experimental demonstrations remain limited. We present a QPE implementation on superconducting processors using the quantum Fourier transform and bit-flip, bit-read error mitigation. Our method estimates energies from QPE data with up to two orders of magnitude higher accuracy than previous limits, lowering computational cost. Results show inherent noise resistance, especially after coherent error mitigation, and outperform prior approaches. This work highlights QPE's practical potential as a high-accuracy algorithm for early fault tolerant quantum computing.

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8 - Evaluating CPW Superconducting Resonators with Engineered α-Tantalum Thin Films

Maria Benito – IMB-CNM

Superconducting Coplanar Waveguide Resonators (CPW) are compact, micrometer-scale devices that absorb electromagnetic energy at specific microwave frequencies.Their tunability enables applications in the fields of quantum information processing, including qubit readout or quantum memories, as well as signal filtering and detection, such as KIDs and SNSPDs. Their ultimate performance relies not only on the proper geometrical design, but is constrained by the quality of the superconducting thin-film material and interfaces. We have recently been developing in-house superconducting chip technologies at IMB-CNM, with a particular focus on CPWs. Our approach combines modeling, fabrication, testing, and simulations, which have allowed improved performance upon technology refinements. Our poster reviews the progress of our CPW portfolio using Aluminium and α-Tantalum Thin Films.

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9 - Hardy's paradox and non-local games with post-selection

Ivan Aljandro Bocanegra Garay – Universidad De Valladolid

Hardy's paradox is a thought experiment to test non-local correlations produced by quantum-mechanical systems [1]. We re-interpret Hardy's paradox as a nonlocal game with post-selection [2]. The statistical power of the resulting post-selection nonlocal game is analyzed and contrasted with the CHSH nonlocal game. By considering the case of detector inefficiencies in experiments with photons, we show that the statistical power in the Hardy game outperforms the CHSH one. This makes the Hardy game more suitable in realistic experimental situations aiming to reject local hidden variables.

[1] Physical Review Letters 79, 2755 (1997). [2] Quantum 4, 353 (2020), arXiv:2005.13418 [quant-ph].

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10 - Operationally classical simulation of quantum states

Alexander Bernal – Instituto de Física Teórica, ift UAM-CSIC

Classical state-preparation devices cannot produce superpositions, hence their emitted states must commute. Building on this elementary observation, we introduce a notion of operationally classical models in which many such devices are stochastically coordinated to simulate quantum states. This leads to many non-commuting quantum ensembles to admit a classical model. We develop systematic methods to either construct these models or prove their impossibility—thereby certifying quantum coherence. In particular, we determine the exact noise threshold above which the entire quantum state space becomes classically simulable. Additionally, we reveal connections between operational classicality and foundational concepts like joint measurability and EPR steering. Our approach is a possible avenue to understand how and to what extent quantum states defy generic models based on classical devices.

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11 - Effective Descriptions in Quantum Mechanics: A Bayesian Inference Problem

Lucas Lauro Brugger – Universidade Federal de Juiz de Fora

Throughout the years, various efforts have been made to reinterpret quantum mechanics from new perspectives. Our work relies upon the approach that frames quantum theory as a generalized formalism for Bayesian inference. Our study embeds the conventional coarse-graining problem within a Bayesian inference setting. We investigate whether generalized inference techniques can be employed to establish necessary and sufficient conditions for the emergence of macroscopic quantum dynamics. As this abstract already hints, we will see that the quantum inference framework, as usually proposed, has its limitations. Furthermore, we will explore how Petz's recovery maps can potentially circumvent these limitations, to find an optimal (in a certain sense) emergent map that remains consistent with the problem across virtually any coarse-graining scenario.

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12 - The entropic coherence is a necessary resource for non-energy preserving gates

Riccardo Castellano – Geneva University

We consider the task of implementing non-energy preserving gates (NEPG) on a finite-dimensional system S via an energy-preserving interaction with an external battery B. We prove that the entropic coherence is a resource for this task, and find a lower bound on its minimum amount that has to be present in the battery to be able to implement NEPGs with a fixed desired precision. An immediate corollary is that any finite-dimensional battery can not exceed a certain minimal error in the gate implementation task. Moreover, under assumptions on the density of energy levels in the battery Hamiltonian, our main results imply additional lower bounds on the minimal amount of energy and quantum Fisher information required to implement any gate. We show that these bounds can be stronger than the universal bounds previously established in the literature.

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13 - Quantum Channels on Graphs: a Resonant Tunnelling Perspective

Giuseppe Catalano – Scuola Normale Superiore, Pisa, Italy

Quantum transport can be significantly enhanced by interference effects, as exemplified by the phenomenon of resonant tunneling. In this work, we investigate quantum scattering on graphs, networks of discrete scattering sites connected by quantum pathways, and develop a formalism that describes the resulting quantum channel induced by the global scattering process. While the mathematical structure used to compute the global scattering matrix from local ones coincides with the Redheffer star product, our approach offers a novel quantum information-theoretic interpretation, in which the entire network acts as a quantum channel mapping input to output ports. We derive the corresponding Kraus operators, characterize the transmission probability, and show how resonant concatenation, a generalization of resonant tunneling, can lead to noise suppression and nonlinear transmission enhancement.

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14 - On-chip photon-pair generation and electro-optic modulation in AlGaAs Bragg Reflection waveguides

Michael Choquer – Université Paris-Cité

Quantum photonic integrated circuits (QPICs) based in the III-V semiconductor AlGaAs are attractive for the monolithic integration of active and passive components maintaining a high degree of photon indistinguishability and entanglement. Further development in AlGaAs requires a low-loss and on-chip interface between classical and quantum degrees of freedom: a natural choice is the linear electro-optic effect, which is exploited in classical optical communications. Combining III-V photon-pair sources with electro-optic modulation has been proposed but not yet demonstrated. We realize electro-optic tuners integrated with state-of-the-art AlGaAs photon-pair sources, validating that photon pairs can be both efficiently generated and manipulated on-chip. These results constitute a step towards complex integrated AlGaAs QPICs with promise for quantum networks.

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15 - Absolute dimensionality of quantum ensembles

Gabriele Cobucci – Lund University

The notion of dimension is fundamental in any theory of physics, since it corresponds to the number of independent degrees of freedom under control in a system. In quantum theory, it is represented by the dimension of the Hilbert space in which a quantum state lives. For a pure quantum state, it corresponds to the number of distinguishable states appearing in the superposition. However, this supposes the existence of a special basis with respect to which the superposition is defined. In our work, we propose a basis-independent notion of dimensionality for ensembles of quantum states. It is based on whether a quantum ensemble can be simulated with states confined to arbitrary lower-dimensional subspaces and classical postprocessing. We also develop both analytical and numerical criteria for its certification.

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16 - Quantum Communication through finite-dimensional lossy channels

Sofia Cocciaretto – Scuola Normale Superiore - Pisa

Traditionally, Quantum Information, and Quantum Communication specifically, have been focused on qubit-based architectures. Recent results, however, highlighted that higher dimensional architectures (qudit-based) may present advantages both in terms of communication and computation; a family of channels called Multi-level Amplitude Damping (MAD) channels, which are a possible qudit generalization of the well known Amplitude Damping Channels, are able to model energy decay processes that may happen during signal transmission. In this work, the Quantum Capacity of 4-dimensional MAD's is studied, relying on a technique for computing it even outside of degradable and antidegradable conditions. We also characterized the complete region of antidegradability and degradability in the parameter space for a generic d-dimensional MAD using both analytical and semi-numerical methods.

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17 - Quantum-Inspired Tensor Network Models for Ultrafast Jet Tagging on FPGAs

Alberto Coppi – University of Padova

We conduct a systematic study of quantum-inspired Tensor Network (TN) models for real-time jet tagging in high-energy physics, with a focus on low-latency deployment on FPGAs. Motivated by the strict computational demands of the HL-LHC Level-1 Trigger system, we explore TN architectures as compact and interpretable alternatives to deep neural networks. Our models are trained on jet events represented by low-level features of jet constituents. Benchmarked against state-of-the-art deep learning classifiers, they demonstrated competitive performance. We implement quantization-aware training for TTNs and, driven by quantum information methods, we reduce model complexity to meet hardware constraints. For the best-performing models, we evaluate resource usage on FPGA. Finally, this work aims to highlight the potential of TN models for resource-efficient inference in low-latency environments.

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18 - Effects of Different Noise Environments on the Coherence Time of Open Quantum Systems

Pietro De Checchi – University of Padova

Stochastic Schrödinger Equations provide a versatile framework for describing open quantum systems, both as unravellings of quantum master equations and as to derive new ones. In quantum computing, they enable to implement contractive mappings, each trajectory unitary and exploiting measurements in place of parallelization. Understanding unconventional noise effects helps understanding phenomena and aids in engineering environments with tailored properties, notably in correlated regimes where noise can either degrade or enhance coherence and transport. We present a comparison between using a stochastic process or its derived noise as fluctuation sources, focusing on colored-noise-driven correlated dynamics. We highlight deviations from memoryless approaches, and their impacts on coherence times and stationary states.

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19 - Security of DIQKD from multipartite information causality

Lucas da Silva Pollyceno – International Centre for Theory of Quantum Technologies (ICTQT)

The information causality (IC) principle was proposed as a way to bound quantum nonlocality without invoking the full Hilbert-space formalism. Beyond its foundational role, constraining nonlocal correlations via physical principles has direct implications for device-independent (DI) cryptographic security. Here we show that IC alone suffices to guarantee security of quantum key distribution (QKD) protocols against individual attacks by post-quantum eavesdroppers, within a range of quantum-attainable parameters. This follows from a strong monogamy of Bell-inequality violations, proven to arise from the multipartite formulation of IC. In contrast, the original bipartite IC fails to imply such monogamy or to ensure DIQKD security, highlighting the necessity of the multipartite framework.

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20 - Speeding up Lindblad dynamics via time-rescaling engineering

Bertulio de Lima Bernardo – Universidade Federal da Paraíba

Engineering fast quantum dynamics is key to enhancing noisy intermediate-scale quantum (NISQ) devices, enabling protocols within coherence times for larger qubit systems. Shortcuts to adiabaticity (STA) can accelerate such processes, but existing methods for open systems often require non-Markovian dynamics, time-dependent Lindblad operators, or many control fields. We present a new STA-based method for open quantum systems with simple, fully analytical solutions. The fast dynamics are Markovian and governed by time-independent Lindblad operators. Our approach uses time-rescaling of a reference (slow) process without adding complexity: with a suitable choice, it requires only local interactions and the same number of control fields. We illustrate it with a driven two-level system under amplitude damping and the dissipative transverse Ising model.

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21 - A resource-efficient quantum-walker Quantum RAM

Giuseppe De Riso – Scuola Normale Superiore (Pisa)

Quantum Random Access Memory (qRAM) is a crucial component for efficiently implementing quantum algorithms, yet existing architectures face major scalability and implementation challenges. We introduce a new qRAM design based on quantum walkers on graphs, built from a simple two-operation gadget repeated across the routing network. We further present a variant that relies solely on short-range interactions between information carriers while retaining linear scaling in the number of carriers and optimal query complexity. Thanks to its modular structure, the approach is resource-efficient and enhances scalability, offering a promising pathway toward practical large-scale qRAM.

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22 - Breaking Local Indistinguishability with Superposition of Classical Communications

Hippolyte Dourdent – ICFO Barcelona

Logical consistency with free local operations is compatible with non-trivial classical communications, where all parties can be both in each other's past and future - a phenomenon known as noncausality. Noncausal processes, such as the Lugano process, violate causal inequalities, yet their physical realizability remains an open question. In contrast, the quantum switch - a physically realizable process with indefinite causal order - can only generate causal correlations. Building on a recently established equivalence between the SHIFT measurement, which exhibits nonlocality without entanglement, and the Lugano process, we demonstrate that this measurement can be implemented using a quantum switch of classical communications in a scenario with quantum inputs. This shows that successful SHIFT discrimination witnesses causal nonseparability rather than noncausality, refuting prior claims. arXiv:2502.15579v2

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23 - Device-Independent Conference Key Agreement in Graph State Networks

Patrick Dreger Andriolo – Technische Universität Wien

Quantum Key Distribution is one of the most prominent examples of technological advancements supplied by Quantum Theory. The multipartite generalization of such cryptographic scenarios is known as Conference Key Agreement (CKA) protocols.

In the extreme case that parties cannot trust their laboratories, they may employ device-independent (DI) certifications of nonlocal correlations to ensure that their communication is not only based on genuine quantum resources, but also guarantees that their messages are secure against all-powerful eavesdroppers.

In this work, we show that it is possible to construct DI-CKA protocols with networks of graph states. This may contribute to the design of more experimental-friendly implementations - not relying only on GHZ or W states - and allow us to construct more robust Bell inequalities against noise for cryptography.

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24 - Towards Efficient All-Photonic Quantum Repeaters for Long-Range Quantum Communication

Tommaso Feri – University of Trieste

One of the main challenges in achieving long-range quantum communication is overcoming photon loss. Even in the best available optical fibre, losses scale exponentially with distance, leading to rapid signal degradation. We present a scheme where information is encoded in tree-cluster states, enabling fast and reliable communication through a chain of repeater stations. Our approach realizes an efficient all-optical quantum repeater based on a single deterministic quantum emitter per node and on cluster-state encodings with a reduced number of photons, achieved through optimized asymmetric geometries. This architecture provides a minimal and scalable alternative to memory-based repeater proposals, leveraging emerging technologies for deterministic entanglement generation. https://arxiv.org/abs/2501.18693

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25 - Quantum Universal Hypothesis Testing via Pauli Measurement

Cristian Ferrezuelo Oteo – Universidad Carlos III de Madrid

Quantum universal hypothesis testing addresses the problem of discriminating between two possible quantum states when one of them is unknown. Classically, the Hoeffding test achieves the same error exponent as in the case where both hypotheses are known, but an equivalent quantum formulation remains open. A recent approach based on quantum tomography provides one possible test for binary states. In this work, we propose an alternative scheme that relies on Pauli measurements followed by classical post-processing and show that it improves previous results. Furthermore, by applying a refined version of the data processing inequality, we analyze the optimality of our approach. Our results reveal that aligning one measurement axis with the nominal state outperforms randomly chosen bases, and we establish a new bound on the achievable error exponent in terms of the Rotated Petz Recovery Map.

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26 - Bulk Reconstruction of Infinite-Dimensional von Neumann Algebras using a Generalized Reference State

Sebastian Flad – University College Dublin

For more than a decade, the AdS/CFT correspondence has been studied using the machinery of quantum error correction, with holographic tensor network codes developed to rigorously explore key features of subregion bulk reconstruction in a discretized context. However, comparatively little attention has been paid until recently to the application of these tools within an infinite-dimensional operator algebraic framework, despite this being a natural setting for formulating QFT. In this work, we generalize a simple toy model by Kang et al. [Phys. Rev. 2021], prove a classification result concerning von Neumann factor types and investigate under which conditions the holographic encoding can be generated by a stabilizer code.

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27 - From Compton Scattering to Lemonade

Marlene Funck – Leibniz Universität Hannover

Detecting Entanglement under Rotational Symmetries Entanglement is a central resource in many fields of research such as quantum computation, cryptography or even medical imaging. However, the precise description and quantification of entanglement remains an unresolved challenge in many cases. This work investigates entanglement detection in setups with a rotational symmetry. One frequently discussed example for such a setting, gaining attention because of its application in PET imaging, is the Compton scattering of annihilation photons. We derive explicit positive operator-valued measures (POVMs) applicable to any experimental setup exhibiting this symmetry. This enables a mathematically precise quantum information view of such measurements, which in fact does not distinguish between sophisticated experiments - such as Compton scattering - and a laser shot at a glass of lemonade.

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28 - From Rotations to Unitaries: Reversible Quantum Processes and the Emergence of the SU (2) - SO(3) Isomorphism

Vinicius Gonçalves Valle – Federal University of Juiz de Fora

We present an operational reconstruction of the well-known (quasi-)isomorphism between the

groups SU(2) and SO(3), grounded in the physical description of quantum state preparation and evolution. Starting from the connection between vectors in three-dimensional physical space and quantum states of two-level systems, we investigate how reversible transformations—modeled as CPTP maps—give rise to a correspondence between spatial rotations and unitary operations. Our approach reveals how this group-theoretic structure naturally emerges from physical constraints, particularly the preservation of purity and reversibility in quantum processes. Making the abstract correspondence between SU(2) and SO(3) tangible through experimentally meaningful procedures.

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29 - Quantum key distribution rates from non-symmetric conic optimization

Andrés González Lorente – Universidad de Valldolid

Computing key rates in quantum key distribution (QKD) involves minimizing a convex non-linear function, the quantum relative entropy. Standard conic optimization techniques have for a long time been unable to handle the relative entropy cone, as it is a non-symmetric cone, because the standard algorithms can only handle symmetric ones. Recently, however, a practical algorithm has been discovered for optimizing over non-symmetric cones. We adapt adapt this algorithm to compute QKD key rates, obtaining an efficient technique for lower bounding them.

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30 - Will it glue? On short-depth designs beyond the unitary group

Lorenzo Grevink – QuSoft/CWI

For several groups of broad interest in quantum information science, we prove that analogues of unitary designs cannot be generated by any circuit ensemble with light-cones that are smaller than the system size. This implies linear lower bounds on the circuit depth in one-dimensional systems. However, we prove that slightly weaker forms of randomness—including additive-error state designs and anti-concentration in sampling distributions—nevertheless emerge at logarithmic depths in many cases. Our results reveal that the onset of randomness in shallow quantum circuits is a widespread yet subtle phenomenon, dependent on the interplay between the group itself and the context of its application.

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31 - Quantum Computing for Transport Prediction: Exploring Progress and Future Directions

Daniel Guerrero-Domínguez – Technical University of Denmark

Prediction in transportation science is essential for optimizing mobility, logistics, and urban planning, with significant impacts on modern economies. However, many predictive tasks are computationally intensive, challenging traditional models and forecasting techniques. Quantum computing offers a promising alternative to address these complexities. This work examines the state-of-the-art in applying quantum computing to transport prediction problems, identifies emerging trends and methodological limitations, and highlights key research gaps. We conclude by proposing future directions to advance this interdisciplinary field.

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32 - Tensorized Pauli Decomposition Algorithm and its application to Pauli transfer matrices

Lukas Hantzko – Leibniz Universität Hannover

Pauli matrices are ubiquitous in the realm of quantum physics and hold a fundamental importance in many other fields like quantum computing, information, and simulation. Along with the 2 × 2 identity matrix, Pauli matrices form a complete basis, spanning the space of all 2 × 2 matrices. Pauli matrices and their tensor products, the Pauli strings, are used to describe quantum states and Hamiltonians alike, as weighted sums of Pauli strings. Moreover, Pauli strings can be used in the description of general quantum channels and linear maps on multi-qubit systems. The Pauli transfer matrix is the representation of such a map in the basis of Pauli strings. We show cute mathematical tricks we used to speed up the Pauli decomposition (TPD) and the ideas, that we used in the calculation of the Pauli transfer matrices (PTM). https://doi.org/10.1088/1402-4896/ad6499 https://doi.org/10.1088/1402-4896/ade8b3

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33 - The Born Ultimatum: Simulability in Quantum Generative Models. Capturing Correlators from Data.

Mario Herrero González – University of Edinburgh

Quantum generative models, like their classical counterparts, are data-driven, and their performance depends on the structure of the underlying distribution. In this work, we examine the Quantum Circuit Born Machine (QCBM) through the framework of correlations. Describing the probability distribution in terms of these correlations allows for truncation and surrogate training using tensor networks or Pauli propagation, independently of the chosen loss function. This perspective enables us to move beyond the two-qubit layer ansatz used in passed literature, highlighting that higher-order correlators can be both significant and trainable. Finally, we take an initial step towards analysing the potential advantage in scaling when the QCBM is trained classically and deployed in a quantum computer, once again by means of correlations.

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34 - Quantification of quantum dynamical properties with two experimental settings

Tzu-Liang Hsu – University of Manchester

Characterising quantum dynamics is essential for quantifying properties of a quantum process, such as its ability to generate entanglement. However, current methods require experimental settings that scale with system size, leading to artefacts from experimental errors. Here, we propose an approximate optimisation method that estimates arbitrary property measures using only two mutually unbiased bases. This system-size independence avoids error accumulation and allows characterisation of intrinsic dynamics. Experimentally, we validate the method on photonic fusion and controlled-NOT operations, achieving accurate property estimation with just 10 and 2 Pauli experimental settings, respectively. These results show that our method is suitable for characterising quantum dynamics in platforms ranging from chip-scale processors to long-distance networks.

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35 - Quantum Advantage in Identifying the Parity of Permutations with Certainty

Arnau Diebra Huertas – Universitat Autònoma de Barcelona

We establish a sharp quantum advantage in determining the parity (even/odd) of an unknown permutation applied to any number $n \geq 3$ of particles. Classically, this is impossible with fewer than n labels, being the success limited to random guessing. Quantum mechanics does it with certainty with as few as $\sqrt{n}$ distinguishable states per particle, thanks to entanglement. Below this threshold, not even quantum mechanics helps: both classical and quantum success are limited to random guessing. For small n, we provide explicit expressions for states that ensure perfect parity identification. We also assess the minimum entanglement these states need to carry, finding it to be close to maximal, and even maximal in some cases. The task requires no oracles or contrived setups and provides a simple, rigorous example of genuine quantum advantage. https://doi.org/10.48550/arXiv.2508.04310

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36 - Industrial integration and field deployment of CV-QKD systems

Manon Huguenot – LIP6/Exail

Protocols using continuous variables (CV) allow for the use of standard telecommunication components. Recent studies show that high key rates can be achieved using CV-QKD. An important challenge is to develop industry-grade compatible with stable performance in field conditions. This is the objective of the project QKISS which is part of the European Quantum Communication Infrastructure. We have performed an in-depth exploration of different configurations at both the optical system and control and processing levels, optimizing crucial parameters such as the excess noise in the system and the secret key rate. This resulted in the development of a robust, efficient demonstrator that we have tested in deployed optical fiber infrastructures, we then advanced toward the engineering and production of an industrial-level solution. We are involved in efforts at the European level towards the formal validation and certification of QKD devices and interoperability experiment.

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37 - Exploring the limits of many-body quantum metrology via adiabatic dynamics

Víctor Izquierdo – Universitat Autònoma de Barcelona

The fundamental limits of ground-state metrology impose an upper bound on how precisely unknown Hamiltonian parameters can be estimated. However, bridging these limits with the dynamical Heisenberg bound remains unresolved. Here we first show how to approach the ground-state bound by controlling two-body interactions. Next, we construct an explicit link to the dynamical bound by employing adiabatic protocols on the controllable part of the Hamiltonian so the system follows its ground state throughout the evolution. When local adiabaticity is enforced, both the Heisenberg and ground-state metrology bounds can be saturated in certain models. We illustrate these ideas with a spin-squeezing Hamiltonian, a two-mode Bose–Hubbard model, and two critical quantum many-body systems: the transverse-field Ising model and the XXZ Heisenberg model.

38 - Fermionic Advantage at Some Distributed Computing Task

Fatemeh Moradi Kalarde – Inria de Saclay

We demonstrate that fermionic systems can exhibit an advantage over distinguishable particles and bosons at some distributed computing task. More precisely, we construct a distributed collaborative game whose objective is to generate a prescribed target set of distributions. The game can be won using fermionic resources, but not with distinguishable or bosonic ones. The setting is fully distributed: the parties act locally, performing only local measurements or sending systems to their nearest neighbors. This result establishes a clear separation between the capabilities of fermionic and non-fermionic resources in multipartite distributed scenarios.

39 - Practical RB using improved filter functions

Ake Köhne – CWI

Randomized benchmarking (RB) is a standard technique for measuring the average error of a quantum gate set. The method involves running random gate sequences of varying lengths and sampling from a filter function based on the measured distribution. For long enough sequences, the obtained signal will decay exponentially in the sequence length. The rate of this decay provides a reliable measure of the average gate error. However, subleading decay components often obscure the main signal, especially with noisy or multi-qubit systems. Here, we introduce novel filter functions to suppress these unwanted components. Our simulations, based on Weingarten calculus and experimental tests on the IBM Quantum computer, demonstrate how these new filter functions improve the accuracy of determining the decay parameter and correctly characterizing the error rates of the quantum computer.

40 - Quantum non-Demolition measurements on Thin Film Lithium Niobate

Janot Vilaró Jolis – Université Paris-Saclay

The second quantum revolution is bringing quantum technologies closer to real-world use. Among many approaches, photonic integrated circuits (PICs) stand out, with leading companies in quantum computing and communications basing their architectures on innovative PIC designs. This work explores a scheme to permorm on-chip quantum non-demolition (QND) operations by exploiting the properties of lithium niobate (LN), particularly the thin-film lithium niobate on insulator (TF-LNOI) technology. QND operations ensure a quadrature of the field remains invariant after measurement and can also be seen as a CNOT gate in continuous variables (CV), enabling promising applications in quantum information processing.

41 - Self-Testing Slater states

Arturo Konderak – CFT PAN

Self-testing is a procedure that refers to characterizing uniquely quantum states and quantum strategies from the set of quantum simulations. It has been proved that all entanglement quantum states can be self-tested in the bipartite case, while for general multipartite systems, a complete characterization is still missing. We propose a strategy that allows us to self-test a specific class of multiparticle states, namely, the Slater states, which are multipartite antisymmetric states. Interestingly this strategy is powerful as the number of local dimensions and measurement is constant and independent of the number of parties.

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42 - Hardware-inspired Continuous-Variables Quantum Optical Neural Networks

Todor Krasimirov Ivanov – Barcelona Supercomputing Center

A physically-realizable architecture for continuous-variable quantum optical neural networks is introduced, in which each layer consists of a photon addition operation and a general Gaussian unitary, inducing full-system non-Gaussianity through the photon delocalization phenomenon. For classical simulation, a method based on the Wick–Isserlis theorem is used, permitting exact evaluation of expectation values on the resulting non-Gaussian states without truncating the infinite-dimensional Hilbert space. The proposed design combines readily available single-photon sources, linear-optical interferometers, and homodyne detection, yielding an experimentally feasible framework. Through a variety of tasks, the architecture is shown to balance resource efficiency with strong expressivity and generalization capabilities, illustrating its potential in machine learning and quantum applications.

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43 - From Gadgets to Tensor Network Warm Starts: Reinforcement Learning for Quantum Architecture Search

Akash Kundu – University of Helsinki

Designing efficient quantum circuits is challenging due to exponential state growth and hardware limits. Gadget Reinforcement Learning (GRL) addresses this by combining reinforcement learning with program synthesis, extracting reusable composite gates ("gadgets") from simpler solutions to expand the agent's action space and enable better exploration and knowledge transfer. Despite strong results, scalability issues persist for larger systems. TensorRL-QAS builds on GRL by integrating tensor network methods, using MPS-based, physics-informed circuit initializations to narrow the search space and accelerate convergence. This achieves up to 10× depth reduction, 100× fewer evaluations, and robust scaling up to 20 qubits while maintaining chemical accuracy.

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44 - Deterministic GKP state generation with programmable photonic nonlinearities

Javier Lalueza Puértolas – UAB

Bosonic codes have emerged as a solid alternative to traditional strategies for implementing quantum error correction. One such example is the GKP code, whose structure and inherent symmetries make it a promising candidate for encoding logical qubits, offering strong protection against photon loss. Despite its significant advantages, the experimental realization of GKP states remains a major challenge. This work introduces a platform-agnostic protocol for preparing GKP states, using available resources in state-of-the-art photonic quantum platforms. By solely using 10 quantum gates, we obtain fidelity values up to $|\mathrm{F}| \approx 95\%$ with mean photon numbers of $<\hat{N}> \approx 24$, yielding better results than state-of-the-art protocols for GKP state generation.

Poster Session II, Thursday

45 - Noise-Resilient Quantum Gates Using Geometric and Topological Phases

Oussama Latifi – Mohamed 5 university in Rabat, Morocco

This poster explores geometric quantum computation (GQC), a method for creating quantum gates that are inherently resistant to noise. We review how GQC has evolved from slower, adiabatic concepts to faster nonadiabatic schemes that are still highly robust. We look at how these gates are implemented on modern superconducting qubit platforms like Transmons and Fluxoniums, and discuss the control techniques needed to achieve record-high fidelities. Our work highlights that combining the natural robustness of GQC with advanced engineering is key to overcoming hardware imperfections and moving toward scalable, fault-tolerant quantum computing.

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46 - Experimental Private Quantum Networked Sensing

Nicolas Laurent-Puig – Sorbonne Université - LIP6

Quantum sensors enable highly sensitive measurements of physical quantities, such as Earth's gravitational field, tiny magnetic variations, or time. They rely on quantum states that encode information through interactions with the target quantity. While individual sensors can be precise, entangled probes enhance measurement accuracy. Distributed quantum sensing extends this by entangling spatially separated sensors. A key challenge is ensuring sensors across different parties operate as intended for the sensing task, motivating the merger of quantum cryptography and sensing. Shettell et al. introduced privacy for sensor networks, ensuring both cooperative estimation benefits and protection of local data. Building on this, we study a multi-user quantum sensor network, focusing on privacy in parameter estimation using a four-party GHZ state source.

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47 - Hybrid Benchmarking of Quantum Algorithms

Andreea Lefterovici – Leibniz Universität Hannover

Hybrid benchmarking is an alternative way to asymptotic worst-case analysis, gauging the performance of a fault tolerant quantum hardware platform for solving real-world instances of optimisation problem. Our objective is not to estimate the theoretically optimal performance, but rather to assess the practical performance for quantum routines commonly used in the quantum computing literature. Our overall strategy is to evaluate how the quantum algorithm would perform under idealised assumptions and to identify the ranges where a quantum algorithm could potentially be useful. We address hybrid benchmarking in three ways: gate count, query count, and cycle count.

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48 - Fundamental signaling limits with causally nonseparable quantum processes

Zixuan Liu – Université libre de Bruxelles

Causally nonseparable processes, which arise when quantum mechanics is assumed to hold locally, allow the causal order between events to be in a state of quantum indefiniteness. In this work, we characterize the limits of two-party signaling with causally nonseparable processes and identify constraints on signaling correlations that are direct analogues of the no-simultaneous-encoding and information-causality principles of standard quantum theory. Our results establish a rigorous connection between causal order and the possibility of perfect signaling and reveal how foundational principles of quantum mechanics bound the power of indefinite causal order. This provides a new perspective on the axiomatization of quantum theory in scenarios with indefinite causal structure.

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49 - Characterization of the non-Gaussian entanglement structure for finite stellar rank states

Carlos E. Lopetegui Gonzalez – LKB-Sorbonne Universite

We introduce a general framework for the analysis of non-Gaussian entanglement in bosonic states of finite stellar rank. The central result is the full characterization of their entanglement structure through an atomic decomposition of their stellar polynomial, to which we associate a structural graph, whose connected components determine the mode-intrinsic entanglement content of the state. An essential ingredient in this construction is the concept of essential variables, which identify the effective number of modes involved in a core state, akin to the symplectic rank. Building on this, we derive complete separability criteria for two-mode states, and for stellar-rank-2 states across arbitrary number of modes.Through several examples we illustrate how the method isolates genuinely non-Gaussian resources and quantifies preparation complexity.

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50 - Extrapolation of quantum measurement data

Konstantinos Manos – Institute for Quantum Optics and Quantum Information - IQOQI, Vienna

We consider the problem of predicting future averages of a collection of quantum observables, given noisy averages at past times. The measured observables, the initial state of the physical system and even the Hilbert space labelling of the latter are unknown; we nonetheless assume a promise on the energy distribution of the state. In this unexplored framework, one can find very surprising phenomena, such as self-testing dataset, aha!-Datasets and fog banks. On the computational side, we prove that the extrapolation problem is efficiently solvable up to arbitrary precision through hierarchies of semidefinite programming relaxations.

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51 - Continuous variable systems: Gaussian States in quantum communication, an overview.

Dennis Itzel Martínez Moreno – Universidad de Valladolid

In this work, an overview of Gaussian states will be presented. These states, which include coherent, squeezed, or thermal states, can be implemented in several protocols within the **continuous variable (CV) quantum communication** research field. This approach offers some advantages compared to its counterpart, discrete variable (DV) quantum communication. These advantages lie from the fact that CV quantum communication is often more efficient in terms of cost and scalability, due to the CVs of light can be effectively manipulated using quantum-optical techniques and measured by means of highly efficient coherent detection. Therefore, this talk will provide an introduction to these concepts and the research field, highlighting some characteristics and briefly describing their use in different protocols such as Quantum Key Distribution, Teleportation, and Quantum Networks.

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52 - QCxAI: Parameter-Shift Saliency for Variational Quantum Classifiers

Sohum Mehta – Illlinois Mathematics and Science Academy

QCxAI introduces an input–parameter-shift saliency protocol for variational quantum classifiers (VQCs) that is hardware-compatible and requires only two circuit evaluations per feature. On a 2×2 dataset with causal ground truth, QCxAI achieves 100% test accuracy and 62.5% perfect saliency matches (25/40). Targeted removals guided by our saliency reduce confidence by 3.5–4.0% versus ≈0.015% for random removals, yielding a 232–274× improvement factor; ratios are large despite small absolute deltas by design. We provide a one-command, seed-controlled pipeline with JSON/CSV exports and reproduce results exactly across configurations. Although intentionally toy-scale, the setting serves as a faithfulness stress test that exposes initialization sensitivity; we outline ensembling and deeper ansätze as scalable remedies and note the method's compatibility with near-term hardware.

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53 - Activation of Genuine Multipartite Entanglement and Genuine Multipartite Nonlocality

Markus Miethlinger – University of Geneva

It is known in quantum foundations that many copies of a local state can exhibit nonlocality, this is not possible for bipartite entanglement. However, recent results show that both genuine multipartite entanglement (GME) and genuine multipartite nonlocality (GMNL) can be activated. Furthermore, GME is recognized as a necessary condition for GMNL in the single-copy regime. Yet, the simultaneous activation of GME and GMNL has not been studied. Here, we show that GMNL can be activated using multiple copies of a biseparable state. For the family of states we consider we identify a biseparability threshold in terms of copies. Using a nonlocal game featuring unbounded Bell inequality violations, we derive a sufficient condition for the states to be GMNL-activatable. This shows that single-copy GME is not necessary for GMNL activation, giving insights into the many copy regime of nonlocality.

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54 - Distinguishing Ordered Phases using Machine Learning and Classical Shadows

Leandro Morais – USP

Classifying phase transitions is a fundamental and complex challenge in condensed matter physics. This work proposes a framework for identifying quantum phase transitions by combining classical shadows with unsupervised machine learning. We use the axial next-nearest neighbor Ising model as our benchmark and extend the analysis to the Kitaev-Heisenberg model on a twoleg ladder. Even with few qubits, we can effectively distinguish between the different phases of the Hamiltonian models. Moreover, given that we only rely on two-point correlator functions, the classical shadows protocol enables the cost of the analysis to scale logarithmically with the number of qubits, making our approach a scalable and efficient way to study phase transitions in many-body systems.

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55 - Dual AOM-based Optical Tweezers system for Precise Cell Manipulation

Paulina Moreno Martínez – Cinvestav-Querétaro

Optical tweezers, pioneered by Arthur Ashkin in the 1970s, enable precise manipulation of microscopic particles using a tightly focused laser beam. This work presents a dual optical tweezer system with acousto-optic modulators (AOMs) for independent, real-time control of two traps. Designed to manipulate MG63 osteoblast-like cells, it provides a platform to study their mechanical properties and interactions under controlled conditions. The system allows dynamic modulation of trap positions and laser intensity, offering exceptional accuracy for investigating cell mechanics, responses to external forces, and intercellular interactions, advancing applications in biophysics and regenerative medicine.

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56 - Harnessing the effects of generalized measurements on quantum circuits for temporal information processing

Oriol Morguí Sancho – Institute for Cross-Disciplinary Physics and Complex Systems (IFISC-CSIC)

Quantum reservoir computing is a machine learning framework used for time-series processing consisting in a quantum system (reservoir) that processes input data and generates a quantum state from which information is extracted to perform machine learning tasks. The way in which the quantum state is measured, affects the reservoir's ability to perform these tasks, as the state of the reservoir is perturbed by measurement back-action. While most proposals in the literature neglect the impact of this back-action, recent studies have begun to explore its effects through the use of partial or weak measurements. In this work, we study how coupling the reservoir to a set of ancillary qubits using different interactions to perform a generalized measurement affects the performance of the reservoir.

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57 - Multimode Squeezed States in Telecom and the Production of Non-Gaussian States induced by Thin-Film Waveguides

Peter Namdar – Laboratoire Kastler Brossel, Sorbonne Université

Extensive spectro-temporal control is vital for quantum optical applications. Beyond generating multimode Gaussian states, non-Gaussian features are essential to achieve quantum computational advantage. We present an improved multimode squeezed state source in the telecom regime and outline its extension towards non-Gaussian state generation. Our source demonstrated squeezing across 21 frequency modes. Upgrades such as broader local oscillator bandwidth and adaptive wavefront shaping enhance coherence and squeezing performance, while providing feedback on waveguides. We also advance towards pulse-by-pulse detection, enabling fast protocols. As a next step, we target mode-selective single-photon addition and subtraction, based on theoretical frameworks adapted to our source and transferable to other regimes.

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58 - Digital reconstruction of non-classical states in continuous-variable quantum information

Huy Nguyen – Technical University of Denmark

Digital signal processing (DSP) has driven major advances in optical communications and, more recently, continuous-variable quantum key distribution (CV-QKD). Yet its use for reconstructing non-classical states, such as squeezed states, remains underexplored. Conventional homodyne detection relies on a phase-locked local oscillator from the same laser and precise polarization alignment, requiring complex feedback systems and manual control. These constraints hinder practical deployment beyond laboratory settings. We propose and experimentally demonstrate a DSP-based method that digitally reconstructs squeezed states post-measurement, removing the need for optical phase-locked loops. This approach simplifies the distribution of squeezed light through fiber channels and paves the way for practical applications in quantum communication and distributed quantum sensing networks.

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59 - Swap Network Augmented Ansätze on Arbitrary Connectivity

Teodor Parella Dilmé – ICFO

Efficient quantum state parametrizations are key for hybrid quantum-classical algorithms. A major challenge is adapting to limited qubit connectivity, which restricts correlations between distant qubits. We introduce an algorithm that optimizes qubit routing via swap networks, enabling direct interactions across arbitrary connectivities. Embedding these networks into layered, connectivity-aware ansätze improves trainability and reduces resources. Benchmarks on spin-glass and molecular models show consistently lower energy errors with fewer gates, shallower circuits, and fewer parameters than standard baselines.

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60 - Advanced Superconducting Thin films for Quantum applications. Technology Developments and Modelling

Carlo Pepe – IMB-CNM-CSIC

With Quantum Tech as a disruptive frontier, superconducting thin films emerge as crucial building blocks. We explore complementary approaches to tailoring their performance. E.g. high-quality Nb thin films were developed with the available equipment at IMB-CNM. Initial attempts suffered from Nb oxidation, impurities, and poor electrical contact, but using Ta capping layer effectively protected Nb, enabled reliable cryogenic characterization, and demonstrated superconductivity on several substrates, albeit at Tc below the bulk value. In parallel, advanced processing and simulations are applied to study e.g. ion irradiation effects on Al thin films. Experiments combined with BCA modeling revealed correlations between irradiation dose, vacancy generation, crystalline degradation, and electron-phonon coupling. Results highlight our versatility for advancing superconducting thin films devices

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61 - Adaptive Quantum Imaginary Time Evolution for Efficient Ground State Preparation

Luca Petru Ion – Universitat de Valencia

Preparing ground states of quantum many-body systems is a central task in quantum simulation, with applications in condensed matter physics and quantum chemistry. Imaginary time evolution provides a natural way to filter excited states, but its non-unitary dynamics cannot be directly implemented on quantum hardware. Quantum Imaginary Time Evolution (QITE) approximates this with unitary operations, though at the expense of heavy classical post-processing and deep circuits. We propose an adaptive QITE scheme that reduces both costs by lowering the frequency of costly classical updates and merging unitaries to shorten circuits. We study its behavior under different Trotterizations, truncation thresholds, and system sizes, and find that adaptive QITE may offer a more practical route to ground state preparation on NISQ devices.

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62 - Limits of Quantum Algorithms for Dissipative Partial Differential Equations

Oskar Pfeffer – Physikalisch Technische Bundesanstalt

Quantum algorithms promise exponential speedups for solving high- dimensional linear PDEs. However, for dissipative, time-dependent PDEs, recent results show that quantum algorithms' time complexity depends critically on the decay of the solution's L2 norm, limiting practical speedups in these cases. In this work, we provide an alternative proof of this lower bound by mapping the solution of PDEs to quantum matrix-vector multiplication. The worst-case time complexity is then given by the condition number of the evolution operator or the multiplication matrix, respectively. For dissipative, homogeneous PDEs where the differential operator is not anti-Hermitian, this results in a computational overhead that is exponential in the evolution time. In contrast, for inhomogeneous PDEs, the exponential overhead can vanish if the time evolution of the forcing term is unitary.

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63 - Non-markovian dynamics of a qubit due to accelerated light in a lattice

Marcel Augusto Pinto – Università degli Studi di Palermo

We study the emission of a qubit weakly coupled to a one-band coupled-cavity array with a frequency gradient, where photons experience a synthetic force F. For strong F, emission becomes reversible and maps to an effective Jaynes–Cummings model, leading to chiral, time-periodic excitation of the array, directed right or left depending on the qubit frequency. For weak F,

instead, a complex non-Markovian decay with revivals arises, akin to mirror-induced dynamics in waveguides, but here due to the finite energy band that confines photon motion. In a suitable regime, the decay is captured by a delay differential equation analogous to that of an atom in a multimode cavity, where cavity length and photon travel time are replaced by the amplitude and period of Bloch oscillations

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64 - Quantum Jacobi Algorithm for the Pressure Poisson Equation in Lid-Driven Cavity Flow

Louisa Piskol – Volkswagen AG

Quantum computing has the potential to accelerate large-scale simulations in Computational Fluid Dynamics (CFD) and to enable Direct Numerical Simulation of turbulent flows. In CFD, solving the Navier-Stokes equations often reduces to solving large systems of linear equations. While classical solvers avoid direct matrix inversion in favor of iterative methods, many quantum algorithms like HHL rely on inversion. Recent work [arXiv:2404.08605] has shown that the classical Jacobi iteration scheme can be mapped to a Quantum Jacobi Algorithm. This work applies the Quantum Jacobi Algorithm to the pressure Poisson equation arising in the treatment of a 2D lid-driven cavity flow using Chorin's projection method. We investigate the implementation of the algorithm for this specific use case and analyze its resource scaling across different grid sizes.

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65 - Can outcome communication explain Bell nonlocality?

Lucas Porto – Sorbonne Université

A central aspect of quantum information is that correlations between spacelike separated observers sharing entangled states cannot be reproduced by local hidden variable (LHV) models, phenomenon known as Bell nonlocality. If one wishes to explain such correlations by classical means, a natural possibility is to allow communication between the parties. In particular, LHV models augmented with two bits of classical communication can explain the correlations of any two-qubit state. Would this still hold if communication is restricted to measurement outcomes? While in some restricted scenarios the answer is yes, if a model is required for every projective measurement we prove that for any qubit-qudit state the answer is no. Hence, outcome communication does not explain all qubit-qudit correlations.

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66 - Seedless randomness extraction for measurement-device-independent quantum random number generators

Pablo Tikas Pueyo – Quside

This work introduces a seedless randomness generation protocol within a measurement-device-independent framework. The protocol employs a trusted source preparing two non-orthogonal quantum states while treating the measurement device as untrusted and potentially adversarial. A composable security proof, derived from a semidefinite-programming bound on the adversary's guessing probability, enables certified randomness extraction without auxiliary seeds. Validation

through simulations using a quantum entropy source based on polarization switching in VCSELs demonstrates improved efficiency over fully device-independent approaches, indicating a viable route toward robust, practical seedless quantum randomness generation.

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67 - From dynamical to steady-state many-body metrology: Precision limits and their attainability with two-body interactions

Ricard Puig – EPFL

We consider the estimation of an unknown parameter θ via a many-body probe. The probe is initially prepared in a product state and many-body time-independent interactions enhance its θ sensitivity during the dynamics and/or in the steady state. We present bounds on the quantum Fisher information, and corresponding optimal interacting Hamiltonians, for two paradigmatic scenarios for encoding θ: via unitary Hamiltonian dynamics, and in the Gibbs and time-averaged dephased state, two ubiquitous steady states of many-body open dynamics. We then move to the specific problem of estimating the strength of a magnetic field via interacting spins and derive two-body interacting Hamiltonians that can approach the fundamental precision bounds. Finally, we analyze the transient regime. Overall, our results provide a comprehensive picture of the potential of many-body control in quantum sensing.

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68 - Extracting energy via Gaussian operations

Frank Ernesto Quintela Rodríguez – Scuola Normale Superiore di Pisa, Universidad Autónoma de Madrid

Quantum thermodynamics often involves constrained operations and resources. For systems with quadratic Hamiltonians and Gaussian unitaries, optimal work extraction is defined as Gaussian ergotropy. We derive closed-form expressions for Gaussian ergotropy in bosonic and fermionic cases, resembling standard eigenvalue-based formulas. We prove its additivity, showing no advantage from Gaussian entangling operations in multi-copy scenarios. By linking ergotropic and entropic functions, we establish bounds between Gaussianity and extractable work. Finally, we extend the framework to open systems, analysing optimal state preparation that minimises energy output in bosonic Gaussian channels.

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69 - Monitored Ergotropy and Quantum Correlations

Maria Eduarda Reichmann Filippetto – The University of Manchester

This work investigates the maximum extraction of thermodynamic work from quantum systems via cyclic unitary transformations, known as ergotropy, and its connection to quantum correlations. While previous studies related ergotropy gain to discord and concurrence, such correlations vanish in some cases where a gain still occurs. To address this, we focus on realism-based non-locality as a possible resource. For Bell-diagonal states, we show that this correlation indeed underlies the ergotropic gain. Furthermore, using a monitoring measurement map, we implement weak measurements to determine the daemonic ergotropy, and demonstrate that our results differ from those obtained with the selective weak measurement protocol.

70 - Extending Entropic Uncertainty Relations in QKD to multiple measurements

Maik Romancewicz – University of Siegen

Uncertainty is a fundamental property of quantum mechanics, and entropic uncertainty relations (EURs) provide a means to quantify and use it for various applications. EURs play a central role in analysing the security of quantum key distribution (QKD) protocols, especially in the finite-size regime. For the case of two different measurement settings, many useful relations are well-established and have been used to analyse QKD protocols such as BB84, obtaining high key rates and strong security guarantees. However, their applicability to study more complex QKD protocols, employing multiple measurements, such as the six-state-protocol, or higher dimensional systems, remains limited. In this work we study how to extend these relations, aiming to provide new results that can be useful in analysing the security of more complex QKD protocols.

71 - Extremal Structures for Quantum Measurements: Anticoherent Bases and Coherent State Designs

Marcin Rudziński – Jagiellonian University Kraków

This work explores geometrically optimal quantum measurement structures with metrological advantages. We present orthonormal bases of anticoherent states—saturating fundamental uncertainty limit and optimal for rotation sensing—featuring Platonic symmetries that enhance experimental feasibility. Complementarily, we develop efficient operator expansions using spin-coherent state sets, connecting these to spherical t-designs for resource-effective quantum estimation. These dual approaches converge in symmetric configurations like Platonic solids, which simultaneously serve as maximally quantum-sensitive bases and enable direct computation of physical observables via Husimi function sampling at symmetry-determined points. The framework establishes new connections between geometric extremality, measurement optimality, and experimental robustness in quantum metrology. https://doi.org/10.22331/q-2024-01-25-1234

72 - NMR Quantum Kernels Enable Machine Learning with Quantum Data

Vivek Sabarad – IISER Pune

Quantum kernel methods extend classical kernel approaches into Hilbert spaces of quantum systems, enabling richer representations for machine learning. While most implementations focus on classical inputs, we present a quantum kernel capable of handling genuinely quantum data. Using a 10-qubit NMR setup, we encode both classical information and non-parameterized unitary operators as inputs. After experimentally validating the kernel with classical regression and classification tasks, we implement the quantum kernel with quantum inputs to classify entangling vs. non entangling quantum operations. This demonstrates the potential of quantum kernels to bridge classical learning tasks and fully quantum data processing for machine learning.

73 - Sequential realization of Quantum Instruments

Soham Sau – Research Center for Quantum Information, Institute of Physics, Slovak Academy of Sciences

Most of the currently developed devices for quantum technologies aim to implement quantum circuits. Measuring, resetting, and reusing qubits during the running computation is often becoming possible via mid-circuit measurements. Quantum instruments form the mathematical formalism for mid-circuit measurements. It describes a measurement procedure that, in addition to capturing measurement statistics of an induced POVM, also captures the post-measurement state. We prove how any quantum instrument (T) can be realized as an adaptive sequence of two instruments, while the first instrument is allowed to be chosen from Lüders instruments that are defined by postprocessings of the instrument's (T's) induced POVM. We generalize this result to any finite number of steps of the adaptive sequence and investigate the resources required in terms of required ancillary dimensions.

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74 - Group-Theoretic Construction of Variational Quantum Algorithms

Marvin Schwiering – Leibniz Universität Hannover

We present a group-theoretic framework for constructing Variational Quantum Algorithms (VQAs) for constrained optimization problems at the example of the Traveling Salesman Problem (TSP). Building on the analysis of the TSP's symmetry group, we derive hard-coded quantum mixing operators that ensure feasibility preservation and provide reachability guarantees at finite-depth. Specifically, we introduce a family of permutation sequences for the symmetric group S_n that enable a VQA for the TSP with only $\Theta(n \log n)$ parameters, achieving asymptotically optimal scaling within the framework. Our construction provides explicit quantum circuits requiring only a constant number of ancilla qubits. Beyond the TSP, this group-theoretic approach highlights how classical structural insights can systematically inform the design of quantum algorithms.

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75 - Unveiling Connections between Tensor Network and Stabilizer Formalism by Cutting in Time

Zhong-Xia Shang – University of Hong Kong

Tensor network and stabilizer formalism are two main approaches for classical simulations of quantum systems. In this work, we explore their connections from a quantum resource perspective. For the tensor network approach, we show that its complexity, quantified by entanglement, is governed by the interplay of two other types of quantum resources, coherence and magic. Crucially, which one has the predominant influence on entanglement is elucidated by what we term the time entanglement. As time entanglement increases, the dominant resource shifts from coherence to magic. For the stabilizer formalism approach, we propose an operator stabilizer formalism, whose complexity always relies on magic. Therefore, as the time entanglement increases, the governing resources between the two approaches change from being uncorrelated to highly correlated.

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76 - Purely quantum memory in closed systems observed via imperfect measurements

Jorge Tabanera-Bravo – Max-Planck-Institute for Multidisciplinary Sciences

The detection and quantification of non-Markovianity, a.k.a. memory, in quantum systems is a central problem in the theory of open quantum systems. There memory is as a result of the interaction between the system and its environment. Little is known, however, about memory effects induced by imperfect measurements on closed systems, where an entanglement with the environment is not possible. We investigate the emergence and characteristics of memory in closed systems observed via imperfect stroboscopic quantum measurements yielding coarse-grained outcomes. Whereas the conditions for Markov dynamics under "von Neumann" lumping are the same as for classical dynamics, quantum-lumping requires stronger conditions, i.e. the absence of any detectable coherence.

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77 - Tight Bounds for Device-Independent Cryptography with Qudits via Semidefinite Programming

Tigita Takali – Northwestern Christian University, Cape Town

We derive tight bounds for device-independent cryptography using d-dimensional qudits via semidefinite programming. In a generalized E91 protocol, we achieve key rates up to 0.847 bits per qudit for d = 3 under 15% depolarizing noise—representing a 23% improvement over qubit-based protocols. Our convex optimization framework leverages the Collins-Gisin-Linden inequalities for qudits, attaining Bell violations up to 2.914 for d = 4. Dual certificates verify optimality within numerical tolerance. We establish robustness bounds demonstrating protocol stability for noise levels up to 18.3%, including finite-key corrections for block sizes $n \geq 104$. The semidefinite hierarchy exhibits geometric convergence, requiring only a few levels for high precision. Key contributions include explicit key rate formulas for depolarizing channels, optimal measurement settings, and certified robustness radii.

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78 - Optimal randomized measurements for a family of non-linear quantum properties

Yifan Tang – Freie Universität Berlin

Quantum learning encounters fundamental challenges when estimating non-linear properties due to quantum mechanics' inherent linearity. Although recent advances in single-copy randomized measurement protocols have achieved optimal sample complexity for specific tasks, extending them broadly without losing optimality remains an open problem. This work introduces the observable-driven randomized measurement (ORM) protocol to estimate $\mathrm{Tr}(O\rho^2)$ for an arbitrary observable: an essential quantity in quantum computing and many-body physics. We prove its optimality in sample complexity for all Pauli observables, closing a gap in the literature. Furthermore, we develop a tomography-based braiding randomized measurement protocol (BRM) for estimating non-linear properties, which obtains the favorable log-scaling while estimating multiple non-linear observables simultaneously.

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79 - Towards violation of Bell inequalities by position measurements for Dirac particles

Anuradha Tonipe – International Centre for Theory of Quantum Technologies, University of Gdansk

The natural extension of hidden variables to the realm of relativistic physics would be a hypothetical theory in which trajectories (i) exists, consistent with a local hidden variable (LHV) model, and (ii) remains subluminally. Interestingly, the simplest inequality arising from these assumptions in the bipartite case is satisfied by the Dirac equation. This suggests that its dynamics could, in principle, be simulated by LHV theories with causal (i.e., subluminal) trajectories. Motivated by this, we aim to explicitly refute LHV theories for the Dirac equation, drawing an analogy to similar results established for the Schrodinger equation. In this work, we present evidence supporting such a refutation and outline steps towards its quantitative assessment.

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80 - Achieving quantum-limited sub-Rayleigh identification of incoherent sources with arbitrary intensities

Danilo Triggiani – Politecnico di Bari

Diffraction limits the resolution of direct imaging systems, hindering the identification of incoherent optical sources, such as celestial bodies and fluorophores. Recent advances in quantum sensing have shown that this limit can be circumvented through spatial demultiplexing (SPADE) if specific intensity distributions are considered. Here, we develop a general model for incoherent light with arbitrary intensity and compute the quantum Chernoff exponent for generic incoherent-source discrimination problems, with particular focus on the subdiffraction regime. We show that SPADE measurements are not always quantum-optimal. Nevertheless, our analysis can be used to find the best SPADE configurations. Our results advance the theory of quantum-limited optical discrimination, with possible applications in diagnostics, automated image interpretation, and galaxy identification.

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81 - Emergent Bell Phase in an Electromechanical Quantum Simulator

David Ullrich – University of Copenhagen

Suspended carbon nanotubes (CNTs) hosting electrostatically defined quantum dots allow exceptionally strong and tunable electromechanical coupling as well as mechanical modes that can reach the quantum ground state of motion simply by cryogenic cooling. This makes them a unique platform for quantum simulation of electron-phonon coupling. Here, we propose an experiment with two such CNTs in parallel, each hosting four quantum dots (QDs). Surprisingly, we find not only phonon-mediated Coulomb attraction but also a robust phase with a maximally entangled Bell state. Our work outlines a realistically achievable experiment which may enable quantum simulation of hitherto not-understood phases of two-dimensional materials and unconventional superconductors.

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82 - Disentangling signaling and causal influence

Leonardo Vaglini – Aix-Marseille University

The causal effects mediated by a quantum interaction are studied, modelling the latter as a bipartite unitary channel. We define two functions that quantify the amount of signaling and causal influence conveyed by an arbitrary unitary channel. We then show a continuity theorem for causal effects of unitary channels: a channel has small causal influence iff it allows for small signaling. Morover, the functions are proved to be continuous and monotonically increasing with respect to the tensor product of channels. Finally, signaling and causal influence are analytically computed for the quantum SWAP and CNOT gates, in the single use scenario, in the n-parallel uses scenario, and in the asymptotic regime. A finite gap is found between signaling and causal influence for the CNOT, thus proving the existence of extra causal effects that cannot be explained in terms of communication only.

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83 - Information Bottleneck in Quantum-Inspired Machine Learning

Guillermo Valverde – Vicomtech

The information bottleneck is a key result in deep learning theory, explaining learning mechanisms and providing a formal modeling basis. In parallel, quantum-inspired techniques, especially Tensor Networks, are used in machine learning for neural network compression and tensorization, reducing parameters and inference time. While typically evaluated by accuracy, we propose an information bottleneck perspective to analyze learning in tensor models. Following the original methodology, we measure shared information after each activation w.r.t. input and label, using Hilbert–Schmidt Independence Criterion (HSIC) instead of mutual information. Results show tensor models follow similar bottleneck principles to deep networks, influenced by hyperparameters like activation, enabling robust learning dynamics characterization and comparisons.

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84 - Numerical solutions for the H2+ ion dissociation under strong electromagnetic field

Tomás Marcelo Veas Orellana – Universidad de Concepción

In this work, we intend to show numerical solutions to the dissociation of H2+ ions under a strong electromagnetic field by considering both classical and quantum nuclei, as well as a static electron in a single energy level, and a non restrained electron that can occupy a quantum superposition of energy levels, focusing on how the different approximations affect the physical predictions. Our work intends to clarify the differences between the Born-Oppenheimer approximations and a full quantum description of the molecular dissociation that has relevance in the study of quantum control. Finally, this work suggest under what conditions it is sufficient to carry quantum simulations on the single leveled regime to reduce computational costs, while keeping the relevant quantum phenomena intact.

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85 - Non-Projective Bell State Measurements

Amanda Wei – Inria

In this work, generalizations of the well-known Bell state measurements are constructed from equiangular tight frames of maximally entangled states (i.e., a set of maximally entangled states, where every pair is equally, and in a sense maximally, distinguishable.) We prove that there exists no larger BSM on two qubits by showing that no six-outcome BSM is possible. Finally, we study the nonprojective BSM in the contexts of both local state discrimination and entanglement-assisted quantum communication. Our results put forward natural forms of non-projective joint measurements and provide insight into the geometry of entangled quantum states. PhysRevA.110.042206

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86 - Autoencoder-Based Anomaly Detection of Phases in Multi-Band Extended Bose-Hubbard Models

Yuma Watanabe – ICFO

The Bose-Hubbard (BH) model with long-range interactions has recently been realized in excitonic systems. Multi-band BH models accurately describe such systems, and exploring their phases is crucial; however, this is challenging due to the ample parameter space and inherent complexity. Traditional numerical methods require prior knowledge or intuition about the target systems and phases. To address these challenges, label-free, unsupervised machine learning techniques have been introduced for phase classification tasks in many-body physics. Autoencoder-based anomaly detection has been applied to the extended BH model to map out entire phase diagrams, including previously unknown phase-separated states. In this work, we apply such schemes to multi-band extended BH models, aiming to uncover unknown phases and surpass conventional analysis.

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87 - GridGenQ: Hardware design utility for distributed quantum decoders

Ankit Zalawadiya – Riverlane Ltd.

Quantum Error Correction (QEC) turns unreliable physical qubits into useful logical qubits. Hardware-based decoders that use Field Programmable Gate Array (FPGA) or Application Specific Integrated Circuits (ASIC) technologies are the most promising solutions in terms of speed and scalability. However, the design methodology for these solutions typically suffers from long lead times and a lack of flexibility. We propose GridGenQ, a hardware design utility that automates part of the FPGA/ASIC design methodology for distributed QEC decoders. We show that with our novel solution, development time for such distributed hardware decoders can be reduced from several weeks to few minutes. This allows for fast prototyping of distributed decoder architectures to meet the requirements posed by a dynamic QEC landscape.

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88 - Fast quantum measurement tomography with dimension-optimal error bounds

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We introduce a computationally light protocol for quantum measurement tomography. The method applies least-squares estimation to obtain an unconstrained POVM approximation, then projects it onto the set of valid POVMs. We prove upper and lower bounds on the sample complexity of the protocol that match in the system dimension, establishing the protocol's optimality, and test it on a noisy superconducting quantum computer.

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89 - Multi-partite CVQKD: A Star Network and Beyond

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The advancement of continuous-variable (CV) quantum communication enables the co-existence and integration with existing telecommunication infrastructure. In order for broad real-world implementation, it is desirable to support key generations across multiple Bobs with high secret key rate (SKR), cost-effectively operate with off-the-shelf components as much as possible, as well as under everyday conditions and room temperature. In this work, we first demonstrate CV-QKD with four users using probabilistically shaped QAM64; the discrete modulation is often utilized in classical telecommunication. With two users active, we achieved positive key rates of 0.0146 and 0.0186 bit/channel use.
