ICE-10: Quantum Information in Spain

Report of Abstracts

Abstract ID : **216**

Quantum sensing of a quantum field

Content

Estimating a classical parameter encoded in the Hamiltonian of a quantum probe is a fundamental and well-understood task in quantum metrology. A textbook example is the estimation of a classical field's amplitude using a two-level probe, as described by the semi-classical Rabi model. In this work, we explore the fully quantum analogue, where the amplitude of a coherent quantized field is estimated by letting it interact with a two-level atom.
For both metrological scenarios, we focus on the quantum Fisher information (QFI) of the reduced state of the atomic probe.
In the semi-classical Rabi model, the QFI is independent of the field amplitude and grows quadratically with the interaction time τ. In contrast, when the atom interacts with a single coherent mode of the field, the QFI is bounded by 4, a constant dictated by the non-orthogonality of coherent states. We find that this bound can only be approached in the vacuum limit. In the limit of large amplitude α, the QFI is found to attain its maximal value 1.47 at $\tau = O(1)$ and $\tau = O(\alpha^2)$, and also shows periodic revivals at much
later times. When the atom interacts with a sequence of coherent states, the QFI can increase with time but is bounded to scale linearly due to the production of entanglement between the atom and the radiation (back-action), except in the limit where the number of modes and their total energy diverge. Finally, in the continuous limit, where the atom interacts with many weak coherent states, this back-action can be simply interpreted as spontaneous emission, giving rise to the optimal interaction time and QFI rate.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **217**

Heat operator approach to quantum stochastic thermodynamics in the strong-coupling regime

Content

Open quantum systems exchange heat with their environments, and the fluctuations of this heat carry crucial signatures of the underlying dynamical processes. Within the well-established two-point measurement scheme and employing thermofield dynamics, we identify a 'heat operator,' whose moments with respect to the vacuum state correspond to the stochastic moments of the heat exchanged with a thermal bath. This recasts the computation of heat statistics as a standard unitary time-evolution problem, allowing us to leverage powerful tensor-network techniques for simulating quantum dynamics. In particular, we exploit the chain mapping of thermodynamic reservoirs to compute heat fluctuations in the Ohmic spin-boson model. The method, however, is general and applies to arbitrary open quantum systems coupled to non-interacting (bosonic or fermionic) thermal environments, offering a powerful, non-perturbative framework for understanding heat transfer in open quantum systems.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **218**

Deterministic randomness extraction for measurement-device-independent QRNGs

Content

A central component of any random number generator (RNG) is a randomness extractor: a procedure that transforms the weakly random string produced by an RNG's noise source into a (usually shorter) string that is ε-close to being uniformly distributed and uncorrelated with a potential adversary's side information. It is a basic result in classical information theory that no deterministic procedure can extract randomness from every noise source. In the literature, three approaches have been developed to circumvent this issue: seeded (resp. multisource) extractors which, in addition to the noise source, take inputs from an independent uniformly random (resp. sufficiently high min-entropy) source; and deterministic extractors tailored to specific families of noise sources.

Recently, the first deterministic extractor for a family of quantum entropy sources was introduced [C. Foreman and L. Masanes, Quantum 9, 1654 (2025)]. In particular, this construction applies to a device-independent setting in which, as the authors show, the distance to ideal of the extracted strings can be bounded by a CHSH violation. The maximum rates currently achievable with this construction, however, are on the order of 0.0025 bits/round (orders of magnitude smaller than those of seeded counterparts), which—in addition to the difficulty of performing loophole-free Bell experiments at a high rate—constitutes a drawback for industrial applications.

In this work, we extend the techniques in the above-mentioned work to the family of measurement-device-independent quantum entropy sources. Specifically, we provide a seedless randomness generation protocol for any setup with two trusted preparations and a single uncharacterized and untrusted measurement. We then test the protocol's performance using a quantum entropy source based on polarization switching in vertical-cavity surface-emitting lasers (VCSELs). The results show finite-key rates comparable with those obtained via seeded extractors and asymptotic rates an order of magnitude above that of the device-independent construction.

Contribution type

Poster

Primary author(s) : FERNÁNDEZ MARTOS, Tomás

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **219**

Distributed Quantum Extreme Learning Machines

Content

This work investigates the design and performance of distributed architectures for Quantum Extreme Learning Machines (QELMs) applied to the task of quantum state reconstruction. The objective is to determine which architectures can effectively recover specific properties of input quantum states, including both linear and nonlinear features, while also quantifying the associated resource requirements in terms of number of measurements and reservoir dimensionality. Two architectures are considered for the reconstruction of linear properties: a standard three-layer QELM and a spatially multiplexed configuration combining multiple independent three-layer units. For nonlinear properties, the study evaluates the multiple-injections architecture and proposes a novel distributed scheme that introduces entanglement between subsystems within a spatially multiplexed framework. Comparative analysis demonstrates that distributed architectures can achieve accurate reconstruction with reduced quantum resources. These findings highlight the potential advantages of distributed models for scalable and efficient quantum information processing.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **220**

A new approximate Eastin-Knill theorem

Content

Transversal encoded gatesets are highly desirable for fault tolerant quantum computing. However, a quantum error correcting code which exactly corrects for local erasure noise and supports a universal set of transversal gates is ruled out by the Eastin-Knill theorem. Here we provide a new approximate Eastin-Knill theorem for the single-shot regime when we allow for some probability of error in the decoding. In particular, we show that a quantum error correcting code can support a universal set of transversal gates and approximately correct for local erasure if and only if the conditional min-entropy of the Choi state of the encoding and noise channel is upper bounded by a simple function of the worst-case error probability. Our no-go theorem can be computed by solving a semidefinite program, and, in the spirit of the original Eastin-Knill theorem, is formulated in terms of a condition that is both necessary and sufficient, ensuring achievability whenever it is passed. As an example, we find that with $n = 100$ physical qutrits we can encode $k = 1$ logical qubit in the W-state code, which admits a universal transversal set of gates and corrects for single subsystem erasure with error probability of $\varepsilon = 0.005$. To establish our no-go result, we leverage tools from the resource theory of asymmetry, where, in the single-shot regime, a single (output state-dependent) resource monotone governs all state purifications.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **221**

Variational quantum regressors for renewable energy forecasting

Content

The growing integration of renewable energy sources has intensified the need for accurate forecasting methods to ensure grid stability. In this context, wind energy—known for its high variability—presents significant forecasting challenges. This project explores the novel application of quantum neural networks (QNNs) for wind power forecasting, positioning quantum machine learning (QML) as an emerging technology with transformative potential compared to classical approaches.

The project serves as a proof-of-concept for the practical use of variational quantum regressors (VQRs) in real forecasting workflows. The quantum circuits leverage angle encoding via Ry/Rz gates, variational layers with entanglement through CNOT gates, and flexible measurement strategies that enable extraction of physically meaningful observables beyond standard expectations (e.g., $\langle Z \rangle$).

The methodology includes three main phases: model development, emulator-based validation (using Qibo and Qiskit), and benchmarking. Multiple QNN configurations were tested, varying circuit depth, entanglement structure, and output observables. All experiments were performed in simulation environments to ensure controlled testing conditions and reproducibility.

QNN performance was benchmarked against traditional regression models—such as random forests, support vector regression, and classical neural networks—using the same dataset. Evaluation was based on metrics like Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), along with qualitative insights into model stability, convergence, and noise sensitivity. Results were documented in technical reports to support internal knowledge transfer, potential patent exploration, and future collaboration with industrial partners.

Ultimately, this project assesses the practical readiness of QML for real-world forecasting in renewable energy. By validating QNN behavior through high-fidelity simulations under realistic constraints, it contributes valuable knowledge to the broader quantum innovation ecosystem.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **222**

Accelerating Quantum Imaginary Time Evolution

Content

Preparing Hamiltonian ground states is a computational task of interest in many fields such as material science, chemistry, and optimization problems. Efficiently preparing ground states for large, strongly correlated systems remains a challenging task even for quantum hardware, especially with the current state of the art. Ground state preparation via Imaginary Time Evolution (ITE) is inspired by natural cooling processes; however, ITE is a non-unitary process. The family of unitary processes designed to approximate ITE falls under the category of Quantum Imaginary Time Evolution (QITE). In this paper, we review the geometric properties of ITE, relate it to geodesic evolution in state space, and propose a metric to quantify the difference between the two. The geometric interpretation aids in introducing our new QITE algorithm, which exploits these geometric properties to reduce both the algorithm's runtime (fewer expectation values) and the depth of the resulting circuit. We perform a numerical study to establish the scaling of fidelities with different truncation parameters, provide quantum and classical resources estimates for each.

Contribution type

Poster

Primary author(s) : ANGLÉS-CASTILLO, Andreu

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **223**

Topological crystals and soliton lattices in a Gross-Neveu model with Hilbert-space fragmentation

Content

We explore the finite-density phase diagram of the single-flavour Gross-Neveu-Wilson (GNW) model using matrix product state (MPS) simulations. At zero temperature and along the symmetry line of the phase diagram, we find a sequence of inhomogeneous ground states that arise through a real-space version of the mechanism of Hilbert-space fragmentation. For weak interactions, doping the symmetry-protected topological (SPT) phase of the GNW model leads to localized charges or holes at periodic arrangements of immobile topological defects separating the fragmented subchains: a topological crystal. Increasing the interactions, we observe a transition into a parity-broken phase with a pseudoscalar condensate displaying a modulated periodic pattern. This soliton lattice is a sequence of topological charges corresponding to anti-kinks, which also bind the doped fermions at their respective centers. Out of this symmetry line, we show that quasi-spiral profiles appear with a characteristic wavevector set by the density $k= 2\pi\rho$, providing non-perturbative evidence for chiral spirals beyond the large- N limit. These results demonstrate that various exotic inhomogeneous phases can arise in lattice field theories, and motivate the use of quantum simulators to confirm such QCD-inspired phenomena in future experiments.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **224**

Toward a Full-Stack Resource-Performance Model for Photonic Quantum Architectures

Content

Lately, photonic platforms have emerged as one of the most promising candidates for large-scale, fault-tolerant quantum computation. Several architectures based on continuous-variable measurement-based
quantum computing (CV-MBQC), particularly those employing Gottesman-Kitaev-Preskill (GKP) encoded qubits,
have been proposed in recent years due to their ability to perform entanglement and gate operations
deterministically, as well as being compatible with concatenated quantum error correcting codes. However,
existing analyses focus on isolated components: error correction codes, photonic sources, or cluster
generation, without evaluating the integrated performance of the full architecture. This work aims to address
this gap by developing a simple, accessible framework to model the end-to-end performance of a photonic
quantum computer. Specifically, the goal is to characterize high-level performance metrics — such as the logical
error rate — in terms of low-level resource parameters, including squeezing levels, the number of resource
generators, and temporal or energetic costs. Such a framework would enable a full technical gap analysis,
identifying bottlenecks and design trade-offs across the whole photonic stack.

Contribution type

Poster

Primary author(s) : FERNÁNDEZ MARTÍNEZ., Marc

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **225**

Activation-aware Tensorization and Compression of Neural Networks

Content

In recent years, the capacity of deep learning models has grown substantially to meet the demands of increasingly complex tasks. However, training and deploying these large-scale models remain resource-intensive due to their massive parameter spaces. To address this, various model compression techniques—such as pruning, knowledge distillation, and quantization—have been developed to reduce computational and memory costs. More recently, quantum-inspired tensor network methods have emerged as a successful compression strategy, giving rise to Tensor Neural Networks (TNNs). In TNNs, some or all weight matrices are factorized into interconnected lower-dimensional tensors—forming a tensor network—that preserves the most significant correlations in the original matrices, and discards less important ones. These correlations are captured by bond indices, leading to an important reduction in trainable parameters and improved efficiency.

However, factorizing weight matrices using techniques such as Singular Value Decomposition (SVD) often degrades model performance, requiring fine-tuning to restore accuracy. Many existing fine-tuning approaches rely on end-to-end training of the tensorized model using a global loss function such as cross-entropy, which is inefficient and memory-intensive.

We propose a novel activation-aware optimization strategy for fine-tuning TNNs, using Matrix Product Operator (MPO) algorithm, where the compressed model aims to mimic the functional properties of the trained dense model, i.e. intermediate output activations. Our method follows a slice-wise procedure: (1) selection of slices to tensorize: where each slice may have one to several layers. (2) Activations recording: input data is passed through the dense model slices and input/output activations of each selected slice are recorded. (3) First MPO approximation (FMA): weight matrices in every slice are factorized via MPO. (4) Slice optimization: fine-tune each MPO slice independently by feeding it recorded input activations and minimizing the difference between its output activations and those of the original dense slice already recorded.

This approach offers several advantages: (i) reduced data needs by leveraging dense activations; (ii) lower memory usage due to per-slice optimization; (iii) easy parallelization across slices, since individual slice optimization is performed independently; and (iv) improved compression quality and faster convergence compared to global fine-tuning, due to localized optimization, as reflected by our experimental studies.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **226**

Marginal second-order moments do not suffice for entanglement detection

Content

The complete knowledge of the global and marginal second-order moments of a quantum state is in general insufficient for entanglement detection. By deriving the conditions on local-unitary (LU) transformations through the second-order moments, we construct pairs of separable and entangled states that are not LU equivalent, contain different amount of entanglement, and are not equivalent under stochastic local operations and classical communication, even though the states share identical global and marginal second-order moments.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **227**

Quantum Simulations of QCD within a particle-based codification

Content

One of the most anticipated applications of quantum information science is the simulation of complex systems. Those involving quarks and gluons are particularly compelling, as their real-time phenomenology remains elusive to computational techniques such as traditional Monte Carlo methods. Overcoming these challenges could provide unprecedented insights into the dynamics of partons.

In this context, we discuss the calculation of fragmentation functions, key to describe how quarks and gluons transform into observable hadrons. As we move along we introduce a series of strategies to face the problem using quantum computers, all grounded in a codification paradigm where particles and their internal degrees of freedom are the central objects.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **228**

Quantum-enhanced metrology using non-Gaussian states

Content

The main goal of quantum metrology consists in devising protocols to improve the precision of parameter estimation beyond the so-called standard quantum limit (SQL). Most of these metrological techniques rely on interferometric schemes, where it is known that two-photon squeezed light can reach a Heisenberg limited precision. In this work, we investigate the performance of non-Gaussian states such as the mth-phase states and mth-order squeezed states—referred to as multisqueezed states—within the same interferometric frameworks, employing the quantum Fisher information (QFI) as the key figure of merit. Our results show that these non-Gaussian states exhibit interesting properties which could be exploited to improve the precision of interferometric sensors in the low occupation regime with respect to the two-photon squeezing, thereby indicating a way for advancing quantum-enhanced metrology beyond the limits of Gaussian states.

Contribution type

Poster

Primary author(s) : GORDILLO HACHUEL, Rubén

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **229**

Design and testing of a silica glass microfluidic device for quantum sensing based on NV centers

Content

This work explores the integration of Nitrogen-Vacancy (NV) center defects in diamonds with microfluidic platforms for advanced studies in fluid dynamics and potential biomedical applications. We have developed and analyzed three distinct silica glass chip designs, aiming to achieve optimal compatibility with a confocal microscope system. Additionally, we present preliminary relaxometry measurements performed using deionized water, which demonstrate that the device functions as intended. This innovative approach seeks to contribute to progress in early disease detection, intracellular environment exploration, and the analysis of fluids at the nanoscale.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **230**

Microwave-free dynamical polarization strategy for 13C near the Ground State Level Anticrossing (GSLAC) in Nitrogen-vacancy centers

Content

Nitrogen-vacancy (NV) centers in diamond represent a powerful platform for spin hyperpolarization, with applications ranging from quantum sensing to nuclear magnetic resonance (NMR) spectroscopy. Traditional approaches to dynamic nuclear polarization (DNP) rely on transferring polarization from the NV center's electron spins—characterized by high gyromagnetic ratios—to nearby nuclear spins such as , which possess longer coherence times. These methods typically require microwave irradiation, posing practical limitations for scalable or in situ applications. In this work, we investigate microwave-free alternatives to the Integrated Solid Effect (ISE), leveraging optimal quantum control techniques near the NV center Ground State Level Anticrossing (GSLAC). This approach offers a potentially simpler and robust route to nuclear spin hyperpolarization, paving the way for more accessible DNP protocols.

Contribution type

Poster

Primary author(s) : HERNÁNDEZ RODRÍGUEZ, Marcos

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **231**

Benchmarking Quantum Machine Learning Models for Multivariable Time-Series Forecasting

Content

In this work we explore the use of quantum machine learning (QML) models for multivariable time-series forecasting. We benchmark a diverse set of variational quantum circuit (VQC) architectures, designed to encode multivariable classical time-series data into quantum circuits for effective temporal modeling and forecasting. These include quantum convolutional neural networks (QCNNs), data re-uploading models, dense embedding strategies, and hybrid quantum-classical pipelines. Our experiments include multivariable synthetic datasets (such as the Lorenz chaotic system) and real-world datasets. In particular, we test our models on a dataset provided by the Instituto Tecnológico y de Energías Renovables (ITER), which contains multiple environmental and operational variables from wind energy infrastructure in Tenerife. We evaluate the models in terms of convergence speed, forecasting accuracy, and behavior under short- and long-term prediction regimes. Our findings indicate that pure quantum models tend to converge faster during training, while hybrid architectures consistently achieve better long-term accuracy. From an architectural perspective, models that process each input variable with independent quantum circuits tend to perform well in short-term forecasting tasks, whereas those that embed all variables jointly into a denser single circuit yield more stable and accurate predictions over long horizons. We aim to explore additional QML architectures and extend our evaluation to a wider range of real-world datasets. We also plan to test the models on the alternative task of forecasting a specific target variable from the full multivariate input, reflecting common needs in practical applications.

Contribution type

Poster

Primary author(s) : BONILLA, Jesús

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **232**

A Decoder-Independent Metric for Evaluating Noise-Aware Implementations of the Steane Code

Content

Understanding how noise affects syndrome measurements is essential for analyzing the behavior of quantum error-correction codes. In a stabilizer code, the stabilizers are operators that leave every codeword unchanged. The syndrome is the set of outcomes obtained by measuring a chosen set of stabilizer generators.
This work focuses on the Steane code and the characterization of the noise introduced during syndrome extraction. The analysis is restricted to Pauli noise, and calibration factors are computed based on syndrome outcomes. These factors quantify how noise alters the measured expectation values before and during measurement and are then combined to capture the overall deviation.
We propose the use of these calibration factors as a figure of merit to evaluate different implementations of the Steane code on simulated real hardware. The implementations differ only in the mapping and routing of qubits. We compare circuits compiled with a noise-aware strategy (that places operations on the most reliable regions of the device) against those compiled without taking error information into account.

Contribution type

Poster

Primary author(s) : RODRÍGUEZ-SORIANO, Laura

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **233**

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

Content

In this work we estimate the unknown parameter of Hamiltonians of the form $H\theta(t) = \theta HS + HC(t)$. We consider two types of probes: (i) The ground state of $H\theta$ and (ii) A unitarily time-evolved state generated by $H\theta$. The sensing performance is
quantified by the Quantum Fisher Information (QFI), denoted by $F\theta$. For both settings, fundamental upper bounds on the QFI are known. However, the set of Hamiltonians attaining these bounds with non-trivial control interactions remains to be determined. We propose experimentally feasible models attaining the ultimate limits of precision in both cases and provide a connection between the two bounds.

Contribution type

Poster

Primary author(s) : L. ANDRÉ, Erik

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **234**

How to make a ”quantum” computer

Content

The rapid rise of quantum computing in sectors such as industry, finance, and energy has attracted strong interest from governments, companies, and investors. A key medium- to long-term development is the acquisition of quantum computers by data centers, businesses, and research institutions—creating a growing market. There are different companies that provide these devices both at the level of integrated structure in supercomputing centers and at the level of small portable devices. However, this expansion raises the critical question of how to certify that a purchased device is genuinely quantum and not a classical simulator disguised as one.

To highlight this concern for businesses and academy, and stimulate further research, we present the design of a fully classical device capable of masquerading as a noisy quantum computer. This system can pass algorithmic tests and counter common accusations of being non-quantum, despite relying solely on classical hardware. Such a device, which could be built for under €2000 even for large amount of qubits, presents a potential avenue for fraud—enabling fake quantum companies and startups to operate with little oversight.

Our proposed system consists of a closed-box design featuring a display or interface for QASM circuit input. Inside, a classical computer (CPU and GPU) performs simulations, while additional components introduce environmental noise to mimic quantum behavior. Claims of proprietary quantum hardware can deflect hardware verification attempts.

Simulations are executed using Qiskit Aer’s AerSimulator, incorporating both realistic and artificial noise models. GPU acceleration ensures fast runtimes, with execution delays attributed to the transpilation process. Noise is gradually increased between executions to emulate decalibration. To handle different circuit depths, both statevector and MPS methods are used. High CPU/GPU usage is explained as required for signal processing and control, while the absence of true quantum randomness is justified as a consequence of decoherence effects.

This work underscores the urgent need for robust quantum certification methods and raises awareness of potential vulnerabilities in the emerging quantum hardware market.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **235**

Approximate Prepare-and-Measures Simulation For d>2

Content

For two non-communicating parties, there are experiment scenarios where quantum theory leads to outcomes that no classical model can describe. However, adding finite classical communication to shared classical resources can make it possible. Prepare-and-Measure and entanglement exemplify this situation and are studied for d=2. Whether this remains possible for d>2 is still an open question. We offer a new perspective on the functionality of protocols for d=2 and exploit it to design a protocol that simulates quantum mechanics exactly for d=2 and approximately for d>2. We investigate the performance of the approximate protocols through a randomized numerical study based on Total-Variational-Distance. We show that our protocol converges to the exact values for d=2, performs best for d=3, and is the second-best for d=4 among the protocols we have investigated. This suggests the analytical structure underlying it hints at an exact protocol for higher dimensions.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **236**

Predictability of quantum observables of top quarks quantum states in QCD.

Content

The ability to predict the outcomes of quantum measurements lies at the heart of both foundational questions in quantum mechanics and practical applications in quantum information processing. In this work, the predictability of top quarks quantum states in colliders, which stand for recent and interesting emerging systems in quantum information[1-4], has been analyzed through statistical classification and regression measures [5]. Specifically, the Bayes risk (for classification problems) and the expected prediction error (also known as inference variance for regression) were used to assess how well quantum observables can be predicted.

The general scenario consists of a bipartite system AB, in which Alice controls quantum system A, and Bob controls an additional subsystem B. Our goal is to determine whether Bob's measurements on system B can help predict the outcomes of Alice's measurements on system A.

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tion: A framework for optimal predictability of quantum observables. 2025

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **237**

A quantum pendulum clock

Content

We investigate an optomechanical system as a model of an autonomous mechanical pendulum clock in the quantum regime, whose operation relies only on incoherent (thermal) resources. The escapement of the clock, the mechanism that translates oscillatory motion into ticks, is provided by an emitter in the optical cavity and the operation of the clock relies on the existence of a limit cycle. Since the clock is based on an oscillatory degree of freedom, it can overcome the thermodynamic uncertainty relation and is thus more accurate than clocks that rely only on stochastic transitions. Furthermore, by increasing the amount of emitters in the cavity, the clock approaches the behavior expected for a macroscopic pendulum clock, where fluctuations become irrelevant while the clock dynamics becomes completely irreversible. This allows for investigating the quantum-to-classical transition of pendulum clocks.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **238**

CUNQA: a Distributed Quantum Computing platform for HPC environments

Content

The challenges of scaling quantum hardware [1] and the emerging view of quantum processors as accelerators within high-performance computing (HPC) environments both underscore the need for distributed quantum computing (DQC) solutions [2]. CUNQA meets this need by offering an emulation platform that spins up virtual QPUs—classical compute nodes dedicated to simulating quantum circuits. These virtual QPUs can operate fully isolated, connected via classical communication, or, in future releases, linked through quantum communication; thereby covering the full spectrum of DQC architectures.

In the first scenario—where the QPUs are entirely isolated from one another—quantum tasks can be distributed classically. This yields a straightforward performance boost: by sending two circuits to different virtual QPUs, they execute in parallel instead of one after the other. The same principle applies to shot distribution, parallel evaluations in variational-optimization workflows, and, more broadly, any classical distribution of quantum tasks.

In the second scenario virtual QPUs can exchange classical information, enabling quantum programs to share data at runtime. For example, a measurement outcome on one QPU can be used to classically control a gate on another. This capability makes it possible to implement algorithms such as Distributed Quantum Phase Estimation [3] or circuit knitting with classical communication [4]. Although tasks are still distributed classically, they must now respect the synchronization constraints imposed by these communications.

In the third scenario, virtual QPUs are linked via quantum communication to emulate a genuinely quantum distribution of tasks. This mode functions as a sandbox for exploring how programs might be structured in a future modular quantum-computing architecture. As previously noted, this functionality remains to be implemented.

Environment management in CUNQA is handled via a lightweight API and command-line interface. The platform supports multiple simulators (e.g., Qiskit Aer, MQT-DDSIM), flexible backend configurations (including custom noise profiles and topologies), and dynamic deployment through SLURM commands. While today's release is tailored to CESGA's infrastructure, upcoming versions will broaden compatibility to encompass additional HPC centers.

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[4] Piveteau, C. \& Sutter, D. 10.1109/TIT.2023.3310797

Contribution type

Poster

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Presenter(s) : VÁZQUEZ PÉREZ, Jorge

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **239**

Distributed Variational Quantum Eigensolver across different noise profiles

Content

In the current NISQ (Noisy Intermediate-Scale Quantum) era, quantum computing faces significant limitations due to the constrained capabilities of Quantum Processing Units (QPUs). Variational Quantum Algorithms (VQAs) have emerged as one of the most promising strategies to harness quantum advantage with current hardware, relying on parameterized quantum circuits optimized via classical feedback loops. However, these algorithms require multiple circuit executions per optimization step. Distributed Quantum Computing (DQC) offers a compelling alternative by leveraging multiple quantum devices that cooperate, enabling parallel execution and reduced execution time.

In this work, we investigate the impact of heterogeneous noise on the performance of VQAs by simulating a distributed quantum setup where each QPU is characterized by a distinct noise profile. In fact, VQA executed on real quantum devices could benefit significantly from noise-aware optimization strategies [1].In order to emulate a DQC environment we employ CUNQA [2], a framework that allows the deployment of virtual QPU on HPC platforms. These virtual quantum machines are allocated on classical resources but intend to emulate realistic backend noise models and topologies, configurable by the user. The target application is the parallelization of the Variational Quantum Eigensolver (VQE), which can be done by different strategies: shots distribution, evaluations of observables, calculation of gradient terms, etc [3].

Concretely, we benchmark different optimizers under different noisy backends and for distributed setups combining them, using shot distribution. In practice, Quantum Natural Gradient (QNG) is effective at finding optimal parameters for the algorithm, except when executed solely on a backend with poor coherence times and low gate fidelities. Nevertheless, when the VQE is parallelized across devices with heterogeneous noise characteristics—including that same backend—QNG still manages to identify parameters that prepare the ground state of the problem Hamiltonian. Future work will study the effects of other distribution strategies.

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Contribution type

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **240**

Quantum computing for the design of antibiotics

Content

Spreading of antibiotic resistance genes is an ecological and public health concern. Synthesising new antibiotics becomes crucial. AMPs (antimicrobial peptides) are an ancient part of the innate immune response across all classes of life. These peptides (short amino acid chains) are potent, broad-spectrum antimicrobials promising as novel drugs. A previous work applies a generative artificial intelligence approach for optimising AMPs [1].

Here, we design a methodology suitable for hybrid quantum-classical algorithms that creates an AMP candidate by comparison to an AMP pool. The algorithm filters brute-force candidates to smooth the synthesis process.

Obtaining the similarity matrix of the amino acids. Six variables, related to antimicrobial functions, characterise the amino acids. We stretch and rotate the 6-variable space using principal component analysis. Thus, we can calculate the disparity between amino acids using the Euclidean distance. If the disparity is 1, the similarity is 0.
Greedily initialising a random peptide for building an AMP candidate. The more similar the amino acid is to the rest, the higher the probability. This criterion defines positive candidates. Negative ones regard the more disparate.
Building a quadratic unconstrained binary optimisation (QUBO) Hamiltonian that compares the AMP candidate to one AMP from the pool. We map the maximum common subgraph problem as a maximum weighted independent set problem [2].
Starting with a random peptide, at each iteration of a hybrid quantum-classical algorithm, a random amino acid is selected and mutated. The chain is compared to a pool of AMPs to identify any subgraph matches. At the end of each iteration, we accept the mutations that improve a loss function. Currently, we obtain the first AMP candidates with the digital annealer due to scalability constraints. However, the algorithm allows exchanging the quantum routine for a variational quantum algorithm. Furthermore, we conduct experimental tests in the laboratory to measure the antimicrobial activity of the AMPs created.

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Contribution type

Poster

Primary author(s) : MUSSA JUANE, MARIAMO

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **241**

Quantum simulation without ancillae

Content

k-local Hamiltonians describe non-trivial k-body interactions in quantum many-body systems. A quantum simulator, in this context, is a k
′
-local Hamiltonian, with k
′ < k, capable of reproducing
the same physical behaviour as a target k-local Hamiltonian. It is well established that certain 2-local quantum simulators—when allowed to operate on an enlarged Hilbert space—can fully capture
the physics of any quantum many-body system, including its ground state, full energy spectrum, excited states, observables, thermal properties, and time evolution. In this talk, we explore the simulatability of quantum many-body systems under the realistic constraint that both the target Hamiltonian and the quantum simulator act on the same Hilbert space, meaning the simulation does
not require introducing ancillary degrees of freedom. We present constructive methods to design simulators of this kind that, whenever feasible, accurately reproduce specific physical aspects of the
target system, particularly i) its ground state, and ii) its dynamical evolution [1, 2]. As a concrete example, we consider the rotated surface code Hamiltonian—a non-periodic, 4-local version of the toric code—and show that, even if its ground-state space cannot be simulated by any 2-local or 3-local Hamiltonian acting within the same Hilbert space, it may appear as an excited eigenspace of such Hamiltonians, up to errors of order machine precision.

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6, 023243 (2024).
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simulators, Phys. Rev. Res. 4, 023228 (2022).

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **242**

Exact fluctuation in a driven-dissipative spin chain

Content

Understanding the dynamics of open quantum systems is a central challenge in modern quantum physics. Among these systems, boundary-driven spin chains have emerged as minimal yet rich models. This study explores the steady-state behavior and current fluctuations in open quantum spin chains subject to boundary driving and dissipation. To this end, advanced numerical techniques based on tensor networks are employed, including vectorization of the Liouvillian superoperator and Matrix Product State (MPS) representations. The approach is validated against known exact results at zero temperature.. The results demonstrate the capability of tensor network techniques to accurately capture steady-state properties and fluctuation statistics in boundary-driven quantum systems.

Contribution type

Poster

Primary author(s) : GEA CABALLERO, Ana Teresa

Presenter(s) : GEA CABALLERO, Ana Teresa

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **243**

Hamiltonian Learning with Reshaping via Quantum Zeno Effect

Content

Determining the Hamiltonian of a quantum system is essential for understanding its dynamics and validating its behavior. Hamiltonian learning provides a data-driven approach to reconstruct the generator of the dynamics from measurements on the evolved system. Among its applications, it is particularly important for benchmarking and characterizing quantum hardware, such as quantum computers and simulators. However, as these devices grow in size and complexity, this task becomes increasingly challenging. To address this, we propose a scalable and experimentally friendly Hamiltonian learning protocol for Hamiltonian operators made of local interactions. It leverages the quantum Zeno effect as a reshaping tool to localize the system's dynamics and then applies quantum process tomography to learn the coefficients of a local subset of the Hamiltonian acting on selected qubits. Unlike existing approaches, our method does not require complex state preparations and uses experimentally accessible, coherence-preserving operations. We demonstrate the feasibility of our protocol both with numerical simulations and through an experimental implementation on IBM's superconducting quantum hardware, successfully learning the coefficients of a 109-qubit Hamiltonian.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **244**

Self-testing tilted strategies for maximal loophole-free nonlocality

Content

The degree of experimentally attainable nonlocality, as gauged by the loophole-free or effective violation of Bell inequalities, remains severely limited due to inefficient detectors. We address an experimentally motivated question: Which quantum strategies attain the maximal loophole-free nonlocality in the presence of inefficient detectors? For any Bell inequality and any specification of detection efficiencies, the optimal strategies are those that maximally violate a tilted version of the Bell inequality in ideal conditions. In the simplest scenario, we demonstrate that the quantum strategies that maximally violate the doubly-tilted versions of Clauser-Horne-Shimony-Holt inequality are unique up to local isometries. We utilize a Jordan's lemma and Gröbner basis-based proof technique to analytically derive self-testing statements for the entire family of doubly-tilted CHSH inequalities and numerically demonstrate their robustness. These results enable us to reveal the insufficiency of even high levels of the Navascués–Pironio–Acín hierarchy to saturate the maximum quantum violation of these inequalities.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **245**

Thermalization in open many-body systems and KMS detailed balance

Content

Starting from a microscopic description of weak system-bath interactions, we derive from first principles a quantum master equation that does not rely on the well-known rotating wave approximation. This includes generic many-body systems, with Hamiltonians with vanishingly small energy spacings that forbid that approximation. The equation satisfies a general form of detailed balance, called KMS, which ensures exact convergence to the many-body Gibbs state. Unlike the more common notion of GNS detailed balance, this notion is compatible with the absence of the rotating wave approximation. We show that the resulting Lindbladian dynamics not only reproduces
the thermal equilibrium point, but also approximates the true system evolution with an error that grows at most linearly in time, giving an exponential improvement upon previous estimates. This master equation has quasi-local jump operators, can be efficiently simulated on a quantum computer, and reduces to the usual Davies dynamics in the limit. With it, we provide a rigorous model of many-body thermalization relevant to both open quantum systems and quantum algorithms.

Contribution type

Poster

Primary author(s) : SCANDI, Matteo

Presenter(s) : SCANDI, Matteo

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **246**

Sensitivity enhancement and quantum correlation detection of non-Gaussian states with measurement-after-interaction strategies

Content

Some non-Gaussian states are highly sensitive to perturbations, providing a significant advantage over Gaussian states in metrological tasks. However, the parameter to be retrieved resides in higher-order moments of non-Gaussian states, making standard linear measurements insufficient for its detection. In our work, we investigate single- and multi-parameter estimation protocols based on measurement-after-interaction (MAI) strategies, where the probe state undergoes an additional evolution prior to linear measurements. We further extend these techniques to the detection of non-Gaussian quantum correlations. By benchmarking both discrete- and continuousvariable systems, we demonstrate that MAI techniques significantly outperform the typical linearmeasurement scenarios in detecting metrological sensitivity and quantum correlations of nonGaussian states, while also showing improved robustness against detection noise.

Contribution type

Poster

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Presenter(s) : GUO, Jiajie

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **247**

Asymmetries of thermal processes in open quantum systems

Content

An intriguing phenomenon in non-equilibrium quantum thermodynamics is the asymmetry of thermal processes. Relaxation to thermal equilibrium is the most important dissipative process, being a key concept for the design of heat engines and refrigerators, contributing to the study of foundational questions of thermodynamics, and being relevant for quantum computing through the process of algorithmic cooling. Despite their importance, the dynamics of these processes are far from being understood. We show that the free relaxation to thermal equilibrium follows intrinsically different paths depending on whether it involves the temperature of the system to increase or to decrease. Our theory is exemplified using the recently developed thermal kinematics based on information geometry theory, utilizing three prototypical examples: a two-level system, the quantum harmonic oscillator, and a trapped quantum Brownian particle, in all cases showing faster heating than cooling under the appropriate conditions. A general understanding is obtained based on the spectral decomposition of the Liouvillian and the spectral gap of reciprocal processes.

Contribution type

Poster

Primary author(s) : TEJERO, Álvaro

Presenter(s) : TEJERO, Álvaro

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **248**

Three-Basis Loop-Back QKD for Scalable Quantum Networks

Content

Quantum computing is poised to revolutionize information processing but simultaneously poses severe threats to conventional cryptographic systems, particularly those relying on public-key infrastructure. As a countermeasure, Quantum Key Distribution (QKD) leverages quantum mechanics to generate provably secure cryptographic keys. However, existing QKD protocols, such as BB84, Twin-Field QKD (TF-QKD), and MDI-QKD, face significant limitations for deployment in complex metropolitan optical networks due to their technical complexity, demanding requirements, or dependence on trusted intermediaries.

This research introduces an advanced QKD protocol known as Three-Basis Loop-Back QKD, designed to overcome these challenges by combining efficiency, scalability, and low experimental complexity. The protocol leverages the round-trip propagation of quantum states, applying unitary polarization transformations before returning them to the sender for measurement. Unlike BB84, which requires public disclosure of measurement bases and yields an effective quantum bit error rate (QBER) of e, the Loop-Back scheme eliminates basis disclosure and reduces the effective QBER to e/(1+e), enhancing security and resilience under realistic noise conditions. Compared to TF-QKD, which requires complex setups with phase synchronization and entanglement sources, Loop-Back operates with standard optical components, simplifying implementation and reducing costs.

The incorporation of three mutually orthogonal bases (X, Y, Z) increases noise tolerance and strengthens detection of intercept-resend and photon number splitting attacks. Moreover, its compatibility with both linear and ring topologies enables scalable, multi-user key distribution without relying on trusted nodes—addressing a critical barrier for QKD deployment in urban environments.

The project focuses on theoretical modeling, computational simulations, and the design of experimental schemes aimed at validating the protocol's performance under realistic conditions. This work contributes a novel, scalable, and experimentally accessible QKD solution, supporting the advancement of secure quantum communications and reinforcing Latin America's position in the global quantum technology landscape.

Contribution type

Poster

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **249**

Characterizing high-dimensional multipartite entanglement from the covariances

Content

High-dimensional entanglement has been identified as an important resource in quantum information processing, and also as a main obstacle for simulating quantum systems. We consider covariances of collective observables and present a generalization of the Covariance Matrix Criterion for determining the Schmidt number of a bipartite system. To show the practical relevance of our results, we derive simpler Schmidt-number criteria that require similar information as the fidelity-based witnesses, yet can detect a wider set of states.

Since entanglement certification is often complicated in practice by the large number of modes and

their sensitivity to random rotations, from our generalized criterion we derive an inequality which requires no common reference frame between parties. This inequality can be used to find regions in the space of moments of randomized correlations. In particular, we find analytical boundary curves for the different entanglement dimensionalities in the space of second- and fourth-order moments of randomized correlations for bipartite systems.

We then implement this method in an experiment, certifying three-dimensional entanglement in a five-dimensional two-photon state using 800 Haar-random measurements. We further demonstrate the robustness of this approach against random rotations by certifying high-dimensional entanglement despite arbitrary phase randomization of the optical modes.

Extending these bipartite criteria to multipartite systems is the next highly non-trivial task. We derive a nonlinear criterion that can reveal both the level of multipartiteness and the dimensionality of the entanglement in the quantum states. We test our condition on paradigmatic classes of high-dimensional multipartite entangled states and find that, in comparison with other available criteria, our method provides a significant advantage.

Beyond discrete-variable systems, we also show that our approach can be adapted to continuous-variable platforms to detect the Schmidt number. This adaptation is especially well suited to setups such as trapped ions and circuit QED, where one typically measures the Wigner function rather than performing homodyne detection, and it outperforms known methods that rely on system discretization.

Contribution type

Poster

Primary author(s) : LIU, Shuheng

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **250**

Novel physically-realizable quantum optical neural networks

Content

A hardware-friendly architecture for continuous-variable quantum optical neural networks (QONNs) is presented alongside a classical simulation technique based on Wick's theorem for computing expectation values of arbitrary continuous observables in specific non-Gaussian quantum states.
The proposed QONN design employs trainable Gaussian operators as linear layers, leveraging their action on optical quadratures in direct analogy to weight matrices and bias vectors in classical neural networks. Nonlinearity is realized via photon-addition operators combined with Gaussian transformations, in contrast to earlier methods that rely on experimentally demanding gates (e.g., cubic-phase or Kerr gates) or measurement-induced operations on ancillary modes. This approach results in a universal model composed of currently available experimental components.
For outputs measured by homodyne detection, an appropriate combination of Gaussian operators, photon addition, and an efficient input-encoding scheme implements effective linear mappings and induces sigmoid-like nonlinear responses through photon delocalization phenomenon.
Benchmarking on supervised learning tasks—such as curve fitting and classification—highlights variations in network depth, squeezing constraints, and the distribution of photon additions across modes. The observed results indicate robust generalization and strong expressivity across diverse architectural configurations.
The QONN's capability to synthesize complex non-Gaussian gates, as the cubic-phase gate, is assessed by training the gate's action over a set of coherent states. Matching statistical moments up to a specified order enables sufficiently deep QONNs to approximate the target gate with decreasing error, paving the way toward experimental realization of advanced non-Gaussian operations.

Contribution type

Poster

Primary author(s) : KRASIMIROV IVANOV, Todor

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **251**

Quantum Integration by Quantum Signal Value Integration

Content

We propose a quantum algorithm for numerical integration of functions. Our approach uses Quantum Signal Processing (QSP) to construct a polynomial approximation of the target function from sampled data, and then applies Quantum Signal Value Transformation (QSVT) to estimate the definite integral with quantum precision. Unlike classical numerical integration methods, which require high sampling density or access to analytic expressions, our method enables efficient integration based on limited discrete information, leveraging the exponential improvement in accuracy offered by quantum algorithms. This makes the method especially suitable for functions that are not well-defined or are difficult to integrate using classical techniques. This work demonstrates how QSVT can be adapted to functional estimation tasks beyond Hamiltonian simulation, positioning quantum integration as a promising tool for future data-driven quantum computing applications.

Contribution type

Poster

Primary author(s) : RENTERÍA ESTRADA, David Francisco

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **252**

Quantum algorithms for algebraic structures and their complexities

Content

Quantum computing has unexpected applications in multiple fields, such as algebra. In this work, we dig into
a variety of different algebraic quantum algorithms for black-box groups, rings and magmas, examining their
complexity. A key result, finding additive generators for any subring, is proved, leading to several subring
problems being reduced to abelian group problems. In particular, the ideality of a subring is solved in quantum
polynomial time. With respect to magmas, we analyze a family of existence problems through a unifying framework, together with a generalization of the Deutsch-Jozsa algorithm that expands its scope while maintaining
its deterministic nature.

Contribution type

Poster

Primary author(s) : LUGILDE FERNÁNDEZ, Guillermo

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **253**

Non-commutativity as a Universal Characterization for Enhanced Quantum Metrology

Content

A key challenge in quantum metrology lies in efficiently leveraging quantum resources to exceed classical limits of precision. While recent works have suggested that indefinite causal order can potentially enable sensitivities surpassing the Heisenberg limit, the underlying physical mechanisms remain poorly understood.
In this work, we introduce the nilpotency index K—a parameter that captures the hierarchical non-commutativity among operators involved in the encoding process—as a fundamental quantity dictating the degree of quantum enhancement.
We demonstrate that a finite value of K leads to a root-mean-square error scaling of $N^{-(1+K)}$
.
Notably, the use of indefinite causal order becomes necessary only when the nested commutators reach constant values.
In the extreme limit where K $\longrightarrow \infty$, an exponential scaling in precision, $N^{-1}e^{-N}$, can be achieved.
We further propose experimentally accessible protocols that realize these mechanisms, offering a systematic route toward the implementation of practical quantum-enhanced sensing strategies.

Contribution type

Poster

Primary author(s) : KONG, Ningxin

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Status: WITHDRAWN

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **254**

Thermodynamic adequacy of the Floquet-Lindblad Master equation

Content

Driven dissipative quantum systems are fundamental in quantum optics, as they describe lightmatter interactions under non-equilibrium conditions. We analyze the thermodynamic consistency of a master equation describing a periodically driven dissipative system. Emphasizing the importance of quantum coherences in accurately capturing energy fluxes, we discuss the validity regime of the Redfield equation and the secular approximation. Arguing in favor of a coarsegraining approach, that leads to partial secularization, we investigate a master equation with GKSL form applicable to arbitrary driving regimes. We support our analysis with two examples: a driven two-level system coupled to a thermal bath and a three-level maser model.

Contribution type

Poster

Primary author(s) : TOLEDO TUDE, Luisa

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **255**

Generating custom circuit cutting decompositions for arbitrary diagonal unitary operators.

Content

Current quantum computers face significant limitations that hinder their ability to deliver consistent and scalable advantage. These include limited gate fidelity, and the susceptibility to noise and decoherence. Additionally, the number of available qubits and their interconnectivity remain constrained, restricting the complexity of executable quantum circuits. Hybrid quantum-classical architectures emerge as a promising tool to leverage the potential of current devices [1]. In such architectures, classical preprocessing and compilation steps play a crucial role by optimizing quantum circuits, reducing qubit overhead, and enabling better mapping of algorithms onto physical hardware.

In this context, several circuit cutting algorithms have been proposed to split the execution of a circuit in different quantum processors [2,3]. However, these methods are not universally applicable;

in practice, they are primarily effective for circuits with low entanglement. This limitation arises because the classical overhead of simulating quantum correlations grows exponentially with the degree of entanglement of the circuit.

In this work, we introduce a novel method to find local decompositions of quantum operations used

for circuit cutting. Given a diagonal unitary operator representing an operation on a quantum circuit, this method provides several local quasi-probability decompositions and their corresponding overheads depending on the available ancillary qubits. This approach offers two key advantages over existing circuit cutting techniques. First, it enables the decomposition of arbitrary-size diagonal operators, with the only limitation being the spectral analysis of the quantum operation. Second, the algorithm allows for the inclusion of additional ancillary qubits at any cut, which can significantly reduce the classical overhead of the simulation.

The techniques introduced in this work can be used to create flexible hybrid compilers adapting the execution of a given quantum circuit to a distributed setup. Moreover, these same techniques can aid in designing distributed ansätze for variational quantum algorithms. Although this work focuses only on diagonal unitary operators, the methods presented can be readily extended to general operators. We leave this exploration for future work.

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Contribution type

Poster

Primary author(s) : RODRIGUEZ-RAMOS, Constantino

Presenter(s) : RODRIGUEZ-RAMOS, Constantino

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **256**

The quest for quantum nonlocality in the smallest triangle network

Content

For years, an answer to the question of whether the triangle network with no inputs and binary outcomes supports quantum network nonlocality has remained elusive. By post-processing known higher-outcome quantum nonlocal distributions, quantum nonlocality was found when two of the parties have ternary outcomes. In addition to this, it is known that this scenario admits PR-boxtype correlations. Yet, all efforts to prove, either, that all quantum realizations admit an alternative classical one, or that quantum nonlocality exists, have not fulfilled their goal.
In this talk I will give the first demonstration of a quantum nonlocal distribution in the no-inputtwo-outcome triangle network, thus demonstrating the existence of quantum advantage in the scenario. In order to find it, it was necessary to combine a recent complete characterization of the corresponding local set [arXiv:2503.16654] and novel methods of exploring the set of quantum realizations in networks, based on higher-order quantum transformations.

Contribution type

Poster

Primary author(s) : POZAS-KERSTJENS, Alex

Presenter(s) : POZAS-KERSTJENS, Alex

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **257**

Time correlations from steady-state expectation values

Content

Recovering properties of correlation functions is typically challenging. On one hand, experimentally, it requires measurements with a temporal resolution finer than the system's dynamics. On the other hand, analytical or numerical analysis requires solving the system evolution. Here [1], we use recent results of quantum metrology with continuous measurements [2,3] to derive general lower bounds on the relaxation and second-order correlation times that are easy both to calculate and measure. These bounds are based solely on steady-state expectation values and their derivatives with respect to a control parameter, and can be readily extended to the autocorrelation of arbitrary observables. We validate our method on two examples of critical quantum systems: a critical driven-dissipative resonator, where the bound matches analytical results for the dynamics, and the infinite-range Ising model [4], where only the steady state is solvable and thus the bound provides information beyond the reach of existing analytical approaches. Our results can be applied to experimentally characterize ultrafast systems, and to theoretically analyze many-body models with dynamics that are analytically or numerically hard.
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Contribution type

Poster

Primary author(s) : DI CANDIA, Roberto

Presenter(s) : DI CANDIA, Roberto

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **258**

Quantum complementarity: A novel resource for exclusion

Content

Complementarity is a phenomenon explaining several core features of quantum theory, such as the
well-known uncertainty principle. Roughly speaking, two objects are said to be complementary if being certain about one of them necessarily forbids useful knowledge about the other. Two quantum measurements that do not commute form an example of complementary measurements, and this phenomenon can also be defined for ensembles of states. Although a key quantum feature, it is
unclear whether complementarity can be understood more operationally, as a necessary resource in some quantum information task. Here we show this is the case, and relates to the task known as unambiguous exclusion. As well as giving complementarity a clear operational definition, this also uncovers the foundational underpinning of unambiguous exclusion tasks for the first time.
Reference: C.-Y. Hsieh, R. Uola, P. Skrzypczyk, arXiv:2309.11968.

Contribution type

Poster

Primary author(s) : HSIEH, Chung-Yun

Presenter(s) : HSIEH, Chung-Yun

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **259**

Entanglement assisted in energy bounded scenario with an application to channel discrimination

Content

Quantum information processing tasks are often studied under varying assumptions on the level of trust placed in the devices involved. The semi-device-independent (SDI) framework aims at balancing theoretical robustness with experimental feasibility. Several versions of the SDI framework exist, depending on the assumptions imposed on the setup involved. In this work, we focus on the energy-constrained SDI model, where the only assumption in a prepare-and-measure scenario is on the energy of the (otherwise uncharacterized) prepared quantum states, measured with respect to some fixed Hamiltonian.
While previous works have studied the correlations achievable under such energy constraints in the absence of quantum correlations between the devices, here we explore the scenario in which the preparation and measurement devices are allowed to share entanglement. Through both numerical analysis and an analytical construction, we show that this generalized setting leads to a strictly larger set of input-output correlations, potentially enabling new applications. In particular, we investigate the implications for quantum channel discrimination and randomness certification.
First, we focus on the problem of distinguishing a given channel C from the identity channel.
In the unconstrained setting, it is known that the ratio between the entanglement-assisted (EA) and non-EA success probabilities is bounded by (1/2+1/√
2)<=1.208, independently of the system's
dimension. In the energy-constrained scenario, we provide a family of qubit channels for which this ratio can be made arbitrarily close to 4/3.
As for the task of randomness certification, to which the energy-constrained framework has already been applied in the literature, we show that the assumption of no entanglement in the corresponding security proofs is not without consequences. Namely, we show that even when the observed correlations are compatible with a non-entangled implementation, an adversary capable of EA behaviors will have a higher guessing probability, thus reducing the amount of certifiable randomness.

Contribution type

Poster

Primary author(s) : D'AVINO, Raffaele

Presenter(s) : D'AVINO, Raffaele

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **260**

Surface code error correction on IBM heavy-hex devices

Content

The recent observation of exponential error suppression in the surface code [1,2] marks a significant step toward realizing large-scale, fault-tolerant quantum computing. We describe the implementation of various surface code instances on IBM's heavy-hex lattice, which necessitates specific modifications to accommodate hardware connectivity constraints [3]. We conduct surface code quantum memory experiments on the latest IBM Quantum devices and identify Z-type logical
errors as the dominant error source. By employing dynamical decoupling techniques, we significantly improve the code's performance, effectively suppressing the errors. Obtaining experimental data from the device, we build a microscopic noise model that helps the decoder make an informed decision that maximizes the probability of recovery. With these optimizations, we observe a belowthreshold regime with exponential suppression of either bit or phase flips. Numerical simulations
indicate that current devices are close to break-even for simultaneous protection against both error types.
References
[1] Google Quantum AI, Nature volume 614, pages 676–681 (2023)
[2] Google Quantum AI and collaborators, Nature volume 638, pages 920–926 (2025)
[3] C. Benito, E. López, B. Peropadre and A. Bermúdez, Quantum 9, 1623 (2025)

Contribution type

Poster

Primary author(s) : BENITO LAMATA, César

Presenter(s) : BENITO LAMATA, César

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **261**

Semiclassical dynamics of discrete Jackiw-Rebbi model

Content

We propose a discrete realization of the Jackiw-Rebbi model on an ion-trap setup, where the displacements of the ions from their equilibrium positions in a zigzag configuration describe the scalar field. Instead of considering the scalar field as a fixed soliton background, we perform a semiclassical analysis of the time evolution of the complete system.
We observe that the kink spreads, affecting the stability of the zero-energy mode.
We characterize entanglement propagation starting from the ground state of the fermion subsystem, as well as the out-of-equilibrium dynamics after a quench.

Contribution type

Poster

Primary author(s) : KAHAN, Alan

Presenter(s) : KAHAN, Alan

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **262**

Sampling Groups of Pauli Operators to Enhance Direct Fidelity Estimation

Content

Direct fidelity estimation is a protocol that estimates the fidelity between an experimental quantum state and a target pure state. By measuring the expectation values of Pauli operators selected through importance sampling, the method is exponentially faster than full quantum state tomography. We propose an enhanced direct fidelity estimation protocol that uses fewer copies of the experimental state by grouping Pauli operators before the sampling process. We derive analytical bounds on the measurement cost and estimator variance, showing improvements over the standard method. Numerical simulations validate our approach, demonstrating that for 8-qubit Haar-random states, our method achieves a one-third reduction in the required number of copies and reduces variance by an order of magnitude using only local measurements. These results underscore the potential of our protocol to enhance the efficiency of fidelity estimation in current quantum devices.

Contribution type

Poster

Primary author(s) : BARBERÀ RODRÍGUEZ, Júlia

Presenter(s) : BARBERÀ RODRÍGUEZ, Júlia

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **263**

Study of the relaxometry technique for sensing with nanodiamonds inside cells

Content

Nitrogen-Vacancy colour centres in diamond have shown to be remarkable candidates for room temperature sensing of chemical and biological systems due to their long coherence times and accessibility. As nanodiamonds, their biocompatibility makes them a strong platform for sensing inside cells, with relaxometry techniques being commonly used to detect the presence of paramagnetic species and free radicals [1, 2]. However, strain damage and charge instability affects the performance of this technique, increasing its variability and limiting the sensitivity of the sensor [3]. In this work, we face this issue by increasing the contrast of alternating relaxometry experiments through the use of Allen-Eberly pulse sequences [4]. Additionally, we sample the incident laser power to study how ionization can affect the output results. We show an improvement in reproducibility of relaxometry measurements.
1 F. Perona Martínez, A. C. Nusantara, M. Chipaux, S. K. Padamati, and R. Schirhagl, "Nanodiamond
Relaxometry-Based Detection of Free-Radical Species When Produced in Chemical Reactions in Biologically Relevant Conditions," ACS Sensors, vol. 5, no. 12, pp. 3862–3869, Dec. 2020, doi: 10.1021/acssensors.0c01037.
[2] K. Wu et al., "Nanoscale detection and real-time monitoring of free radicals in a single living cell under the stimulation of targeting moieties using a nanodiamond quantum sensor," Functional Diamond, vol. 4, no. 1, Dec. 2024, doi: 10.1080/26941112.2024.2336524.
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[4] G. T. Genov, Y. Ben-Shalom, F. Jelezko, A. Retzker, and N. Bar-Gill, "Efficient and robust signal sensing by sequences of adiabatic chirped pulses," Physical Review Research, vol. 2, no. 3, p. 033216, Aug. 2020, doi: https://doi.org/10.1103/PhysRevResearch.2.033216.

Contribution type

Poster

Primary author(s) : MARTÍNEZ MÉNDEZ, Alejandro

Presenter(s) : MARTÍNEZ MÉNDEZ, Alejandro

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **264**

Spin-1 Control of NV Centers via Pulses of Fixed Frequency and Amplitude

Content

Microwave control of the negatively charged nitrogen-vacancy (NV) center in diamond typically relies on a two-level approximation of its spin-triplet ground state, which holds only under high bias magnetic fields or low microwave power. In this work, we present a fully analytical qubit control scheme based on the NV-Effective Raman Coupling (NV-ERC) technique, which enables efficient initialization and readout of the double quantum (DQ) transition without leakage to any third level. This is achieved via an effective Raman coupling mechanism that remains valid in the low-field regime and is well-suited for high-frequency quantum sensing applications. Additionally,
we propose a protocol for implementing fast single-qubit gates on the DQ transition using pulse trains of constant frequency and amplitude, avoiding the need for shaped pulses. We investigate the protocol's robustness against timing errors arising from imperfect knowledge of system parameters or limited phase control. Importantly, we demonstrate that the proposed scheme remains effective even in the presence of uncontrolled electric or strain fields, enhancing their applicability to realistic experimental environments.
1 Cerrillo, J., Oviedo Casado, S., Prior, J.: Low field nano-nmr via three-level system control. Phys. Rev. Lett. 126, 220402 (2021).
[2] Vetter, P.J., Marshall, A., Genov, G.T., Weiss, T.F., Striegler, N., Großmann, E.F., Oviedo-Casado, S., Cerrillo, J., Prior, J., Neumann, P., Jelezko, F.: Zero- and low-field sensing with nitrogen-vacancy centers. Phys. Rev. Appl. 17, 044028 (2022).
[3] López-García, A., Cerrillo, J. Full qubit control of the double quantum transition in NV centers for low-field or high-frequency sensing. EPJ Quantum Technol. 12, 52 (2025).

Contribution type

Poster

Primary author(s) : LÓPEZ GARCÍA, Alberto

Presenter(s) : LÓPEZ GARCÍA, Alberto

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **265**

Architecture-Centric Design of Quantum Neural Networks

Content

Quantum Machine Learning (QML) is a fast-developing field that lies at the intersection of Quantum Computing and classical Machine Learning. While a general and scalable quantum advantage is still an open question, there are already some heuristic algorithms that have shown potential speedups—quadratic or even exponential in certain tasks—which suggests that exploiting quantum features such as superposition and entanglement could lead to new ways of learning from data. Among the different strategies within QML, Quantum Neural Networks (QNNs) have become
one of the most explored models due to their flexibility and compatibility with current quantum hardware. However, QNNs have mostly been studied from a theoretical perspective, with limited attention paid to their implementation on quantum hardware, or the influence of circuit structure and target application on performance, as well as their scalability.
Conceptually, a QNN can be divided into four building blocks: a classical pre-processing layer, a data embedding strategy that encodes classical information into the qubits, a variational quantum circuit (VQC) responsible for the core quantum processing, and a classical learning policy.
In this work, we focus on analyzing the VQC component as a first step towards a broader study of the full QNN architecture. The aim is to understand how the expressibility of a circuit (its ability to explore a large portion of the Hilbert space) and its entangling capacity affect the performance of different QML algorithms. We explore this connection by testing different VQCs in tasks such as Variational Quantum Eigensolvers (VQE) and Quantum Approximate Optimization Algorithms (QAOA) among others, and we analyze how these two metrics correlate with learning performance for a variety of problems. Our results aim to shed light on how architectural choices influence QML outcomes, especially in the context of NISQ devices, where hardware limitations make circuit design a crucial factor. This type of analysis is key to developing co-design strategies, taking into account hardware constraints from the beginning. By better understanding the trade-offs between expressibility, entanglement, and performance, we hope to guide the construction of more efficient and hardware-aware QNNs that can operate within real-world limitations without compromising their computational potential.

Contribution type

Poster

Primary author(s) : MARTÍNEZ SANZ, Rodrigo

Presenter(s) : MARTÍNEZ SANZ, Rodrigo

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **266**

Spectrum Broadcast Structures from von > Neumann-type interaction Hamiltonians with discrete and continuous variables

Content

In this poster presentation we discuss our contributions to the mathematical foundations of the recently established theory of Spectrum Broadcast Structures (SBS). These are multipartite quantum states, encoding an operational notion of objectivity and exhibiting a more advanced form of decoherence. We study SBS and asymptotic convergence to SBS in the case of a central system interacting with N environments via the von Neumann-type measurement interactions, ubiquitous in the theory of open quantum systems. We will be focusing on the case where the system is modeled by an infinite-dimensional Hilbert space and the operators associated with the system in the Hamiltonian have purely continuous spectrum. Such a setup yields mathematical complications that have hitherto not been addressed in the theory of SBS

Contribution type

Poster

Primary author(s) : ACEVEDO, Alberto

Presenter(s) : ACEVEDO, Alberto

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **267**

Phase transitions in the 1-D Galuber Ising model

Content

We investigate the different phases of the 1-D Glauber–Ising model. introduced by R Augusiak et al (2010 New J. Phys. 12 025021), where the interplay between quantum coherence $\gamma \in [0,1]$ and dissipative cooperativity ,$\delta \in [-1,1]$ plays a central role. Using both exact diagonalization, and the density-matrix renormalization-group (DMRG) algorithm, we compute key observables—including two-point spin correlations, magnetic susceptibility, the Binder cumulant, spectral gap, and the entanglement entropy—to locate the critical point and extract its universal scaling exponents. We explored both the finite size case, and the thermodynamical limit. These signatures suggest connections to topological phases and 3 symmetry. Our findings shed new light on the interplay between quantum correlations and thermal fluctuations due to the environment

Contribution type

Poster

Primary author(s) : BERA, Mohit

Presenter(s) : BERA, Mohit

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Tuesday 14 October 2025**

Abstract ID : **268**

Uncertainty relations and entanglement with finite Fourier transformed variables

Content

We explore uncertainty relations for discrete phase-space observables in finite-dimension, focusing on canonical position/momentum observables linked by finite Fourier transforms. Our approach is complementary to the typical way of using finite-dimensional
Heisenberg-Weyl framework (especially discrete-displacement operators) for studying such systems. Utilizing recent finite-dimensional phase-space formalisms, including analogs of Gaussian functions and Fourier matrix eigenstates, we analyze states saturating
the Robertson-Schrödinger uncertainty relation. We extend our approach by embedding the problem in continuous-variable space, redefining displacement and squeezing operators beyond traditional Heisenberg-Weyl frameworks. We also examine uncertainty relations
involving multiple observables, comparing minimum-uncertainty states, and discuss the continuous limit as dimension increases. We discuss applications that include entanglement detection in finite-dimensional systems, akin to covariance matrix criteria in
continuous-variable systems.

Contribution type

Poster

Primary author(s) : THAKURIA, Dimpi

Presenter(s) : THAKURIA, Dimpi

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **269**

Telling different unravelings apart via nonlinear quantum-trajectory averages

Content

Open quantum systems subject to continuous monitoring evolve as stochastic quantum trajectories whose ensemble average recovers the Markovian Lindblad master equation. Different measurement schemes applied to the environment entangled with the system generate different ensembles—unravelings—that correspond to the same master equation but yield distinct trajectory statistics. We distinguish these unravelings through trajectory averages of nonlinear functions of the quantum-mechanical expectation value of an observable. In particular, we analyze the variance of the expectation value across trajectories to differentiate direct photodetection from homodyne detection in the resonance fluorescence of a two-level atom. This approach shows a practical way to reveal how different measurement schemes influence the stochastic dynamics of open quantum systems, and is further supported by IBM Quantum experiments reproducing two synthetic unravelings with identical average evolution but distinct trajectory statistics.

Contribution type

Poster

Primary author(s) : PIÑOL JIMÉNEZ, Eloy

Presenter(s) : PIÑOL JIMÉNEZ, Eloy

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **272**

Fidelity bounds for spin-dependent kicks with pulsed lasers

Content

Excitation of trapped-ion hyperfine qubits with fast Raman pulses allows for faster-than-trap-period entangling gates with qubits of long coherence time for practical quantum computation. We follow a semiclassical approach to characterize the control parameters that optimize the fidelity of single-ion spin-dependent kicks for different number of pulses. Numerical simulations of the dynamics for those operation points provide bounds of the minimum infidelity that can be achieved with fast pulsed protocols. This work lays the foundation for sub-microsecond trapped ion quantum computing.

Contribution type

Poster

Primary author(s) : SAGASETA PAGÁN, Carlos

Presenter(s) : SAGASETA PAGÁN, Carlos

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **273**

Deterministic generation of bosonic states for quantum error correction

Content

Quantum error correction (QEC) is essential in the quest for scalable quantum computers, as it protects quantum information against decoherence and errors. Bosonic QEC encodes information into harmonic-oscillator modes, resulting in less hardware overhead than discrete-variable approaches. In particular, Gottesman–Kitaev–Preskill (GKP) states form the basis of the GKP code, which is one of the most promising schemes for bosonic QEC as it enables correction of displacement errors and photon loss. However, generating GKP states is challenging, and state-of-the-art implementations have only reached small photon numbers and low fidelities. In this work, we introduce a deterministic strategy to generate GKP states with higher photon numbers and state generation fidelities with respect to the physical GKP states. Our strategy is based on optimizing a programmable photonic quantum circuit, formed by a sequence of gates available in state-of-the-art platforms. Our numerical simulations suggest that these programmable quantum circuits can lead to approximate GKP states with mean photon numbers around 20 and fidelities above 0.95. These methods offer a clear path to high-quality GKP states in current platforms, advancing bosonic QEC towards fault-tolerant quantum computing

Contribution type

Poster

Primary author(s) : LALUEZA PUÉRTOLAS, Javier

Presenter(s) : LALUEZA PUÉRTOLAS, Javier

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **274**

Quditto: A Platform for Emulating and Managing Quantum Key Distribution Networks

Content

Quantum Key Distribution (QKD) ensures theoretically unbreakable security by harnessing the principles of quantum mechanics. However, the high cost, limited availability, and complexity of quantum hardware and dedicated infrastructure continue to hinder widespread experimentation and deployment. In this work, we present Quditto [2], an open-source, automated platform designed to emulate QKD networks with high accuracy. By integrating quantum network simulation via NetSquid [1], automated infrastructure configuration using Ansible [4], and standardized key-request interfaces based on the ETSI QKD 014 API [3], Quditto allows users to experiment with QKD systems without requiring physical quantum equipment. Its modular architecture supports customizable protocol implementations, advanced key management strategies, and configurable quantum channel characteristics such as loss and decoherence. We demonstrate the platform's adaptability and realism through emulated network topologies of varying complexity, including test cases involving adversarial conditions and non-ideal channel characteristics.

Contribution type

Poster

Primary author(s) : DIAZ-BRICIO, Angela

Presenter(s) : DIAZ-BRICIO, Angela

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **275**

Flurosecent nanodiamonds for Quantum Sensing

Content

NV centers have become one of the widest and most developed platforms for Quantum Sensing, enabling nanoNMR, high-precision magnetometry and noise spectroscopy. Although the highest sensitivity and optimal axis orientation is reserved to bulk diamond samples, Nanodiamonds can reach environments that the formers do not. Fluorescent NDs can be introduced in biological environments to study subcellular processes, such as inflammatory routes or free-radical production, revealing information that can not be acquired by classical techniques. However, sensing using nanodiamonds presents many challenges, as the signal contrast is very limited. We provide an overview on how to improve the contrast in pulsed experiments using chirped pulses based on the Allen-Eberly model for two level atoms.

Contribution type

Poster

Primary author(s) : MORENO MESEGUER, Jesús

Presenter(s) : MORENO MESEGUER, Jesús

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **276**

Generation of quantum-entangled light in self-pulsing optical cavities.

Content

We characterize the quantum correlations of light generated inside an actively phase-locked type II Optical Parametric Oscillator (OPO). This system consists of a second-order nonlinear crystal within an optical cavity. When the crystal is pumped with a laser at frequency $2\omega_0$, it can generate two down-converted modes with orthogonal polarizations and resonating inside the cavity at frequency ω_s (signal) and ω_i (idler) such as $\omega_s+\omega_i\approx 2\omega_0$. When we also inject light at frequency ω_0, it is found that pulsed stable emission in the form of limit cycles is achieved for a wide range of parameters. These solutions are characterized by a periodic modulation of the light's intensity and phase. While quantum properties of these cavities are well studied in the stationary regime, they have not been characterized yet in this pulsating regime. In this work we find that there exists a high level of entanglement between the signal and idler modes. We provide analytical results within a linearized theory of quantum fluctuations, which are confirmed by numerical simulations of the stochastic phase-space equations that model the quantum dynamics exactly. The next step will consist in proving that the light coming out of the cavity also shows strong entanglement, leading to a practical source of quantum correlated light with a nontrivial temporal profile. From a fundamental point of view, this is interesting as an example of quantum mechanical effects derived from spontaneous time-translationally symmetry breaking.

Contribution type

Poster

Primary author(s) : CUENCA LARÀS, Marc

Presenter(s) : CUENCA LARÀS, Marc

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **277**

Simulation of Polarization Dynamics in Carbon-13-Based Quantum Simulators

Content

Quantum simulation offers a promising route to exploring complex many-body physics beyond the capabilities of classical computation. Leveraging nuclear spin ensembles in diamond, particularly 13C layers coupled to nitrogen-vacancy (N-V) centers, provides a scalable, room-temperature platform for quantum simulation. In this work, we investigate the polarization dynamics within atomically thin 13C spin layers under the NOVEL (Nuclear Orientation via Electron Spin Locking) protocol, a crucial step toward initializing such simulators. Through Tensor Network simulations, we model polarization transfer from an optically initialized N-V electron spin to a nearby layer of interacting nuclear spins. Our results reveal key features such as polarization backflow and blockade effects induced by strongly coupled spins, which can significantly influence the overall spin ensemble dynamics. We show that internuclear dipolar interactions both limit the maximum polarization and facilitate spatial redistribution, driving the system toward a more homogeneous spin state. We also validate a readout protocol based on NOVEL to reconstruct the layer's collective polarization state. These findings provide foundational insight for optimizing dynamic nuclear polarization in engineered 13C layers and advancing their use in practical quantum simulators operating at ambient conditions.

Contribution type

Poster

Primary author(s) : VERDÚ, Antonio

Presenter(s) : VERDÚ, Antonio

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **278**

Unraveling Chaos and Ergodicity in Quantum Battery Charging

Content

Fast and stable population of higher energy levels from low-energy states is crucial in quantum battery (QB) charging protocols. In this talk we explore whether quantum scrambling can be harnessed to accelerate charging and how ergodicity can be exploited to design resilient and stable QBs. By analyzing the dynamics of out-of-time-order correlators, we examine the impact of scrambling on optimal powers and charging times. Our findings indicate that, despite its potential to accelerate the process, scrambling does not necessarily lead to faster charging [1]. Moreover, we introduce the kicked-Ising model as a novel QB candidate [2]. Under the self-dual operator regime, where ergodicity is maximized, we analytically show that our model maximally charges the QB stably. Validating our findings using tensor networks and IBM hardware, our proposal offers a resilient and implementable QB on current platforms.
[1] Romero, S.V., Ding, Y., Chen, X., Ban, Y. Scrambling in the charging of quantum batteries. JHEP 2025, 21 (2025)
[2] Romero, S.V., Chen, X., Ban, Y. In preparation (2025)

Contribution type

Poster

Primary author(s) : V. ROMERO, Sebastián

Presenter(s) : V. ROMERO, Sebastián

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **279**

Daemonic Ergotropy In Continuously Monitored Dicke Quantum Batteries

Content

Dicke quantum batteries represent a paradigmatic model for quantum energy storage. Previous studies have shown that, even in the presence of dissipation and under strong coupling conditions, these systems can exhibit superextensive power scaling in the thermodynamic limit. However, for finite-size systems, the extractable energy, quantified by the ergotropy, vanishes due to the approach to a passive steady state. In this work, we show that by continuously monitoring the photon output from the cavity - using quantum trajectory methods within the framework of open quantum systems - it is possible to restore a superextensive scaling of the ergotropic power even in finite systems, specifically in terms of the so-called daemonic ergotropy. This result highlights the potential of continuous measurement protocols as a practical route toward experimentally realizable quantum batteries.

Contribution type

Poster

Primary author(s) : CENEDESE, Gabriele

Presenter(s) : CENEDESE, Gabriele

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **280**

Absolute separability and entanglability in arbitrary dimensions

Content

Quantum states that remain separable (i.e., not entangled) under any global unitary transformation are known as absolutely separable and form a convex set. Despite extensive efforts, the complete characterization of this set remains largely unknown. In this work, we employ linear maps and convex geometry to derive new sufficient analytical conditions for absolute separability in arbitrary dimensions, providing extremal points of this set and improving its characterization. We extend our results to multipartite states. (until here, the results were presented in https://arxiv.org/abs/2410.22415). We have also used the same inverse map and convex geometry techniques to bound the entanglement that can be achieved, given a certain spectrum, under global unitary transformations using different entanglement measures, providing more insight on the entanglability of mixed states.

Contribution type

Poster

Primary author(s) : ABELLANET, Jofre

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Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **281**

Interferometric Mass Photometry at the Quantum Limit of Sensitivity

Content

We present an innovative optical imaging system for measuring parameters of a small particle such as a macromolecule or nanoparticle at the quantum limit of sensitivity. In comparison to the conventional confocal interferometric scattering (iSCAT) approach, our setup adds a second arm to form a Michelson interferometer that allows us to tune a relative phase. We evaluate the quantum Cramer-Rao bound (QCRB) for different quantum states, including single-mode coherent states, multi-frequency coherent states, and phase-averaged coherent states. Our results show that the proposed setup can achieve the QCRB of sensitivity and outperform iSCAT for all considered quantum states for mass and phase estimation of a particle.

Contribution type

Poster

Primary author(s) : KÖSE, Emre

Presenter(s) : KÖSE, Emre

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **282**

Controllability of systems with a non-canonical singularity.

Content

Phase singularities are topological features present in a wide variety of physical systems, from optical fields to Bose-Einstein condensates (BECs), and have attracted significant interest due to their
potential for encoding and processing information using the orbital momentum. Understanding their dynamics, whether in space during the propagation of structured light, or in time evolving quantum fluids; is therefore of fundamental importance.
In this work, we present a method to follow the trajectory of a phase singularity embedded in a Gaussian beam. Our approach allows us to characterize all the relevant parameters of the system and analyze how they influence the motion of the singularity. By tuning these parameters, we study the dynamics of singularity in three different scenarios: free-space propagation, evolution under a parabolic potential, and in the presence of effective rotation. This allows us to identify the distinct mechanisms that govern the motion in each case.

Contribution type

Poster

Primary author(s) : DE MARIA GARCIA, Sergio

Presenter(s) : DE MARIA GARCIA, Sergio

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **283**

Quantum state exclusion for group-generated ensembles of pure states

Content

Quantum State Exclusion (QSE) is a fundamental task in quantum information theory, where the objective is to rule out specific quantum states from a known set, rather than identifying the exact state. This perspective has deep implications across multiple areas of quantum science, including contextuality, the foundations of quantum theory, and resource theories. Despite its growing relevance, most existing studies focus exclusively on perfect exclusion—strategies that allow for conclusive and error-free decisions—leaving the development of optimal protocols in more general settings relatively unexplored.

In this work, we present a complete analytical solution to optimal QSE for ensembles of pure states generated by finite group actions. We consider both minimum-error and unambiguous exclusion scenarios and derive closed-form expressions for the optimal failure probabilities in each case. Our approach relies on the representation theory of finite groups and uses the Gram matrix of the ensemble as the central object encoding all relevant exclusion information. We show that the performance of an exclusion protocol depends entirely on the spectral properties of this matrix, offering a unified and elegant description applicable to a broad class of state sets.

Crucially, we provide a constructive derivation of the optimal measurement strategies using semidefinite programming techniques. By analyzing the dual problem, we confirm the optimality of our solutions and explicitly construct the corresponding measurements. This not only strengthens existing results but also overcomes the limitations of non-constructive approaches found in earlier literature.

Our findings apply to all finite groups and extend naturally to projective representations, which are physically relevant in systems like spin-½ particles. Furthermore, our results encompass several previously known cases as special instances and suggest broader implications: the derived expressions provide upper bounds for exclusion performance even when the ensemble lacks symmetry.

Overall, our work offers a comprehensive and practical framework for QSE in symmetric settings, with tools and insights that may prove valuable in a wider range of quantum information problems where symmetry plays a key role.

Contribution type

Poster

Primary author(s) : DIEBRA HUERTAS, Arnau

Presenter(s) : DIEBRA HUERTAS, Arnau

Status: SUBMITTED

Submitted by **HERNANI MORALES, Carlos** on **Thursday 16 October 2025**

Abstract ID : **284**

On the Contextuality of Multi-Agent Quantum Paradoxes via Anomalous Weak Values

Content

In this work we investigate the role of quantum contextuality in multi-agent paradoxes by tracing the emergence of anomalous weak values (AWVs). Starting from the logical pre- and post-selection (LPPS) formulation of the Hardy paradox, we construct an explicit one-way LOCC protocol that reproduces its statistics and provides a proof of Kochen–Specker (KS) contextuality. We then embed this construction into a particular extended Wigner's friend argument known as Local Friendliness (LF). In a coarse-grained model where two friends perform joint two-qubit measurements, we show that the LF assumptions lead to a logical contradiction identical to that of the LPPS Hardy paradox, thereby providing a proof of the LF no-go theorem. We further develop two extensions of this model in which the intermediate measurements are implemented as weak interactions. In both cases, the anomalous weak value of −1 arising in the LPPS Hardy paradox is preserved, confirming its robustness as a witness of contextuality in this setting. A complementary fine-grained decomposition resolves each joint measurement into our LOCC-based construction. Although the same logical contradiction is recovered under the LF assumption, the weak measurement schemes in this decomposition no longer exhibit AWVs. This reveals an apparent tension between two seemingly equivalent descriptions, suggesting that the presence of AWVs may depend sensitively on how multi-agent scenarios are modeled.

Contribution type

Poster

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Towards a Regional Quantum Hub: SCAYLE's Integrated Infrastructure for Quantum Research and Services

Content

The rapid advancement of quantum technologies across Europe is prompting the need for infrastructure capable of validating secure communications and advanced computing in realistic conditions. The Castilla y León Supercomputing Center (SCAYLE) meets this need with its Q-Lab, a modular, hybrid quantum laboratory that aligns with EuroQCI standards. Designed for practical experimentation, the Q-Lab connects theoretical research with industrial applications, strengthening the region's involvement in Europe's quantum transition.

Q-Lab integrates physical and emulated quantum systems. Its features include a discrete-variable QKD link (Toshiba) spanning 6.7 km between SCAYLE and INCIBE, which can be extended via external fiber spools; a continuous-variable QKD link (LuxQuanta) connecting SCAYLE and TEDRA; and a research-grade QKD device with configurable parameters. These are complemented by two quantum emulators: the Fujitsu FX700, which is based on the A64FX and has eight nodes (48 cores and 32 GB of RAM per node), enabling 33-qubit circuit simulations with energy-efficient, highprecision performance; and the Eviden Qaptiva 802, which has two Intel Xeon Platinum 8450H processors (with 56 cores each) and 2 TB of RAM, supporting 30-qubit simulations and being ideal for hybrid algorithm prototyping and circuit validation.

A key element of the infrastructure is the deployment of a QKD virtualize acting as a centralized Key Management System (KMS) that emulates multiple QKD endpoints. This allows for the distribution of keys on demand, the creation of virtual links, and the testing of orchestration scenarios across simulated topologies. The infrastructure also incorporates software-defined networking (SDN) orchestration, enabling experimentation with integrated quantum network models. Initial benchmarks report a secure key rate of 300 kb/s at 10 dB. Hybrid workload emulation has successfully executed over 30 qubit circuits on the Qaptiva 802.

Aligned fully with the EuroQCI technical framework, Q-Lab supports the deployment of interoperable quantum networks, catalyzing collaboration between universities, research centers, public institutions and technology providers. Use cases include the secure transmission of data for smart grid pilots and PQC testing in regional healthcare systems, demonstrating its societal and technological impact. SCAYLE's Q-Lab establishes Castilla y León as a pivotal node in the development of Europe's quantum communication infrastructure.

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