ICE-10: Quantum Information in Spain

Report of Abstracts

Abstract ID : **170**

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 can accurately reproduce specific physical aspects of the target system, particularly i) its ground state, and ii) its dynamical evolution. As a concrete example, we consider the rotated surface
code Hamiltonian—a non-periodic, 4-local version of the toric code—and demonstrate that, in general, its ground-state space cannot be simulated by any 2-local or 3-local Hamiltonian acting within the same Hilbert space. Further, we show that the corresponding 2-local boundary Hamiltonian can
simulate its dynamical evolution for a wide range of initial states.

Contribution type

Talk

Primary author(s) : GARCÍA DÍAZ, María

Presenter(s) : GARCÍA DÍAZ, María

Status: SUBMITTED

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

Abstract ID : **171**

Progress towards scalable quantum computing algorithms for HEP

Content

The Standard Model (SM) of Particle Physics is a very complete theory to describe the fundamental interactions at the subatomic level with great precision, with the exception of gravity. However, several of the phenomena observed in nature cannot be described by it, such as the matter-antimatter
asymmetry or the origin of Dark Matter. To test the SM and look for hints that go beyond its predictions with the required precision, several experimental efforts are taking data - such as LHC - or
being designed. These experiments plan to reach unprecedented energies and amount of data - about
1010 tracks per second or more, thus pushing the data challenge to new frontiers when processing these events at the various stages of the experimental pipeline.
Within this context, the use of Quantum Computing for this type of fundamental research seems like the natural choice, since particle physics has quantum mechanics at its core. A recent roadmap outlining the status and opportunities ofQuantum Computing can be found in \[1\]. In this talk, I will
give an overview of recent developments of QC applications in HEP, with a focus on experimental particle physics, as well as prospects on hardware requirements and new research topics within the
fields.
\[1\] QC4HEP Working Group, A. Di Meglio, K. Jansen, I. Tavernelli, J. Zhang et al., Quantum Computing for High-Energy Physics: State of the Art and Challenges. Summary of the QC4HEP Working
Group, PRX Quantum 5 (2024) 3, 037001, arXiv:2307.03236 (2023).

Contribution type

Talk

Primary author(s) : LUCIO MARTINEZ, Miriam

Presenter(s) : LUCIO MARTINEZ, Miriam

Status: SUBMITTED

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

Abstract ID : **172**

Critical Parametric Quantum Sensing - Theory and Experiment

Content

Critical quantum sensing (CQS) is by now a well-established approach, based on quantum properties
spontaneously developed in proximity of phase transitions. Theoretical studies and first experimental demonstrations show that a quantum-enhanced sensing precision can be achieved by exploiting
phase transitions in many-body systems. It has been recently shown that CQS protocols can also be
implemented using driven-dissipative phase transitions, where the thermodynamic limit is replaced
with a rescaling of the system parameters. This class of phase transitions can emerge in small-scale systems, such as quantum resonators with atomic or Kerr-like nonlinearities, and it is of high theoretical and experimental relevance.
Here, we discuss how optimal [1] CQS protocols can be implemented using a critical parametric resonator, without the need to implement and control complex many-body systems. We then show that a collective quantum advantage can be achieved in a multipartite CQS protocol using a chain of
parametrical critical resonators [2]. Finally, we report on the experimental implementation [3,4] of a
driven-dissipative CQS protocol with a superconducting quantum resonator, with direct applications
in magnetometry and superconducting-qubit readout.
[1] U. Alushi et al., Phys. Rev. Lett. 133, 040801 (2024)
[2] U. Alushi et al., Communications Physics 8, 74 (2025)
[3] G. Beaulieu et al., PRX Quantum 6 (2), 020301 (2025)
[4] G. Beaulieu et al., Nat. Comm. 16 (1), 1954 (2025)

Contribution type

Talk

Primary author(s) : FELICETTI, Simone

Presenter(s) : FELICETTI, Simone

Status: SUBMITTED

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

Abstract ID : **174**

Maximal intrinsic randomness of noisy quantum measurements

Content

Quantum physics exhibits an intrinsic and private form of randomness with no classical counterpart. Any setup for quantum randomness generation involves measurements acting on quantum states. In this work, we consider the following question: Given a quantum measurement, how much
randomness can be generated from it? In real life, measurements are noisy and thus contain an additional, extrinsic form of randomness due to ignorance. This extrinsic randomness is not private
since, in an adversarial model, it takes the form of quantum side information held by an eavesdropper
who can use it to predict the measurement outcomes. Randomness of measurements is then quantified by the guessing probability of this eavesdropper, when minimized over all possible input states.
This optimization is in general hard to compute, but we solve it here for any two-outcome qubit measurement and for projective measurements in arbitrary dimension mixed with white noise. We
also construct, for a given measured probability distribution, different realizations with (i) a noisy state and noiseless measurement (ii) a noiseless state and noisy measurement and (iii) a noisy state and measurement, and we show that the latter gives an eavesdropper significantly higher guessing power.

Contribution type

Talk

Primary author(s) : CURRAN, Fionnuala

Presenter(s) : CURRAN, Fionnuala

Status: SUBMITTED

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

Abstract ID : **175**

Swap Network Augmented Ansätze on Arbitrary Connectivity

Content

Efficient parametrizations of quantum states are essential for trainable variational quantum algorithms. A key challenge in their design consists in adapting to the available qubit connectivity, which limits the capacity to generate correlations between distant qubits in a resource-efficient manner. In this work we propose embedding swap networks -structured routines for qubit permutationwithin layered, connectivity-aware ansätze. We introduce an algorithm that optimizes qubit routing
for arbitrary connectivity graphs, resulting in a swap-network–enhanced ansatz that enables direct
correlation between any pair of qubits. This construction significantly improves the trainability of the ansatz, leading to enhanced performance with reduced resources. We showcase these improvements through ground-state simulations of strongly correlated systems, including spin-glass and molecular electronic structure models. Across exemplified connectivities, the swap-enhanced ansatz consistently achieves lower energy errors using fewer entangling gates, shallower circuits, and fewer parameters than standard layered-structured baselines. Results indicate that swap network augmented ansätze provide enhanced trainability and resource-efficient design to capturing complex correlations on devices with constrained qubit connectivity.

Contribution type

Talk

Primary author(s) : PARELLA DILMÉ, Teodor

Presenter(s) : PARELLA DILMÉ, Teodor

Status: SUBMITTED

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

Abstract ID : **177**

Multi-copy activation of genuine multipartite entanglement in continuous-variable systems

Content

In multipartite scenarios in entanglement theory, one has to consider separability with respect to different partitions, which results in a more complicated structure of the state space than in bipartite scenarios. There, states exhibiting genuine multipartite entanglement (GME) form a non-convex
complement to a convex set of biseparable states (convex hull of all states that are separable with respect to some bipartition).
Multi-copy activation of GME is a phenomenon whereby multiple shared copies of certain biseparable states can exhibit GME. This was first shown for isotropic GHZ states and later proven to be generically possible in finite-dimensional systems.
We begin by extending the general proof of GME activation to infinite-dimensional systems. Building on this, we reconstruct presumably GME-activatable continuous-variable biseparable states and
test their GME activatability. We divide our investigation into two areas: Gaussian states and nonGaussian states. While the examination of the entanglement of the Gaussian state can be simplified to the analysis of its covariance matrix, one needs to employ more general techniques for nonGaussian states. We demonstrate that GME activation is possible in continuous-variable systems by
providing explicit examples of GME-activatable non-Gaussian states. For Gaussian states, we apply
a necessary biseparability criterion for the covariance matrix and show that it fails to detect GME activation. In fact, we identify fully inseparable Gaussian states that satisfy this criterion, yet still exhibit GME when considering multiple, and in some cases even single, copies. This highlights that
the covariance-matrix biseparability criterion is not sufficient, even for Gaussian states.
Published at Quantum 9, 1699 (2025).

Contribution type

Talk

Primary author(s) : BAKSOVÁ, Klára

Presenter(s) : BAKSOVÁ, Klára

Status: SUBMITTED

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

Abstract ID : **178**

Tight and self-testing multipartite quantum Bell inequalities from the renormalization group

Content

Attempts to understand multipartite quantum nonlocality are thwarted by the difficulty of devising
quantum Bell inequalities for systems composed of more than a few separate parties. This is problem
is at the same time notoriously hard, and of crucial applicability in device-independent certification,
as well as in the foundations and disputation of quantum theory itself.
In our submission, we introduce a class of tensors that we call tight connectors. Those can be understood as extreme, coarse-graining transformations in a physical theory whose states consist of
quantum probability distributions. If contracted according to some simple rules, tight connectors define an extreme renormalization flow within such theory. When the flow ends at a single-site system, it specifies a normalized, tight quantum Bell inequality. This inequality can be saturated by conducting measurements on a tensor network state that mirrors the topology of the connector tensor network. If each connector within the network is, in addition, fully self testing, then the resulting inequality will self-test, not only the many-body quantum state, but also some specific local
measurement operators.
We link the design of tight, self-testing connectors to the problem of finding pairs of quantum Bell inequalities satisfying easily verifiable constraints. This allows us to devise large, analytic families of tight, self-testing connectors. In turn, those can be used as building blocks of tight, self-testing quantum Bell inequalities for arbitrarily many parties. We observe that, for some of those inequalities, the ratio between the maximum quantum and classical values increases exponentially with the
system size.
Overall, our method provides a modular recipe for the generation of extremal quantum behaviours and associated tight bounds in arbitrarily large systems.
arXiv preprint: 2503.03878

Contribution type

Talk

Primary author(s) : ABIUSO, Paolo

Presenter(s) : ABIUSO, Paolo

Status: SUBMITTED

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

Abstract ID : **179**

Analyzing resources for multi-parameter estimation of unitaries

Content

I will present some of our recent results in the framework of multiparameter quantum metrology and entanglement. First, I will discuss the problem of estimating unitaries from the SU(2) and SU(1,1)
group, in the general case of a 3-parameter unitary [1]. I will present a class of states that represent an
interesting resource for achieving Heisenberg scaling in such a multiparameter estimation problem
with noncommuting generators and then observe that with the more pragmatic method of moments,
where measurement are restricted to expectation values and variances of the generators, the twin-Fock state emerges as the state allowing for Heisenberg scaling in two out of the three parameters.
I will also showcase the analogies between SU(2) and SU(1,1) estimations, especially from a group-theoretic point of view, and outline the potential generalization to SU(d) and SU(p,q) groups.
Afterwards, I will discuss the connection between similar multi-paramter estimation tasks and entanglement monotones, via the relation between the latter and the Quantum Fisher Information matrix
(QFIM) [2]. The relation between entanglement and quantum metrology is typically showcased by the connections between the QFI and multipartite entanglement quantifiers such as entanglement depth. However, in our case we consider the connection between the QFIM with proper entanglement monotones, i.e., functions that do not increase under Local Operations and Classical Communications, remained so far surprisingly under explored. To further emphasize
the significance of our results, we connect these criteria to the achievable precision in multiparameter estimation, which also provides a practical way of experimental implementations. We conclude
by illustrating how our method extends naturally to multipartite scenarios.
[1] Shaowei Du, Shuheng Liu, Frank E. S. Steinhoff, Giuseppe Vitagliano, Characterizing resources for multiparameter estimation of SU(2) and SU(1,1) unitaries, arXiv:2412.19119
[2] Shaowei Du, Shuheng Liu, Matteo Fadel, Giuseppe Vitagliano, Qiongyi He, Quantifying entanglement dimensionality from the quantum Fisher information matrix, arXiv:2501.14595

Contribution type

Talk

Primary author(s) : VITAGLIANO, Giuseppe

Presenter(s) : VITAGLIANO, Giuseppe

Status: SUBMITTED

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

Abstract ID : **180**

Quantum Optimization of Titanium Plate Cutting Using QUBO Formulations: A Practical Approach with D-Wave Annealing

Content

This work presents a practical experience in the use of analog
quantum computing for solving real-world industrial problems, specifically focusing on the optimization of titanium plate cutting. Based on
a Quadratic Unconstrained Binary Optimization (QUBO) formulation
approach, a model is developed to minimize material waste by selecting
optimal combinations of cutting patterns, subject to availability constraints, processing times, and load balancing across machines.
The model is solved using D-Wave technology, which allows us to explore
the current and potential future advantages of quantum algorithms and
the performance of quantum annealers over classical models in addressing NP-Hard problems. Three increasingly complex configurations were
designed: (1) a basic model without time constraints, (2) a model incorporating multiple machines with homogeneous production times, and
(3) a model that includes production times and machines with varying capabilities. Each configuration underwent experimental validation,
demonstrating the feasibility of the quantum approach and yielding nearoptimal solutions with reduced execution times.
The results highlight not only the applicability of the approach in realworld scenarios but also its potential for generalization to other industrial
sectors facing similar challenges (e.g., textile, wood, reverse logistics).
This work thus contributes to demonstrating the tangible value of quantum computing in industry, offering a concrete, replicable use case aligned
with the goals of advanced digital transformation in production processes.

Contribution type

Talk

Primary author(s) : FRANCO GONZALEZ, Cristian

Presenter(s) : FRANCO GONZALEZ, Cristian

Status: SUBMITTED

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

Abstract ID : **181**

Measuring temporal entropies in experiments

Content

We propose a novel experimental protocol to measure generalized temporal entropies in many-body
quantum systems. Our approach involves using local operators as probes to characterize the out-ofequilibrium dynamics induced by a geometric double quench on a replicated system. Such protocol
mimics the path-integral on the corresponding Riemann surface encoding generalized temporal entanglement. We present the results of tensor network simulations of one-dimensional systems which
validate the protocol and demonstrate the experimental feasibility of measuring generalized temporal entropies, and we outline the experimental requirements for implementing these quenches using
state-of-the-art quantum simulators.
Our results provide thus a physical interpretation of the meaning of generalized temporal entropies.
Furthermore, they reveal that the dynamics induced on two replicas of the Ising model in a transverse
field differ qualitatively from the ones of its non-integrable extension, suggesting that generalized temporal entropies can be used as a tool for identifying different dynamical classes in quantum systems.

Contribution type

Talk

Primary author(s) : BOU COMAS, Aleix

Presenter(s) : BOU COMAS, Aleix

Status: SUBMITTED

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

Abstract ID : **182**

Towards Continuous-Variable Quantum Convolutional Networks for Biomedical Imaging

Content

Continuous-variable (CV) quantum computing offers a promising framework for scalable quantum machine learning, leveraging optical systems with infinite-dimensional Hilbert spaces. While discrete-variable (DV) quantum neural networks have shown remarkable progress in various computer vision tasks, CV quantum models remain comparatively underexplored. In this work, we present a feasibility study of continuous-variable quantum neural networks (CV-QCNNs) applied to biomedical image classification. Utilizing photonic circuit simulation frameworks, we construct CV quantum circuits composed of Gaussian gates, such as displacement, squeezing, and beamsplitters to emulate convolutional behavior. Our experiments are conducted on the MedMNIST dataset collection, a set of annotated medical image benchmarks for multiple diagnostic tasks. We evaluate
CV-QCNN's performance in terms of classification accuracy, model expressiveness, and resilience to
Gaussian noise, comparing against classical CNNs and equivalent DV quantum circuits. This study aims to identify the practical trade-offs between DV and CV paradigms for quantum-enhance medical imaging. Our results highlight the potential of continuous-variable models and their viability for future computer-aided diagnosis systems.

Contribution type

Talk

Primary author(s) : LOPEZ, Daniel

Presenter(s) : LOPEZ, Daniel

Status: SUBMITTED

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

Abstract ID : **183**

Quantum Machine Learning model based on qudits for anomaly detection in high-energy physics data

Content

The identification of anomalous events – not explained by the Standard Model of particle physics –
and the possible discovery of exotic physical phenomena pose significant theoretical, experimental
and computational challenges. It is anticipated that these challenges will increase significantly with
the operation of next-generation colliders, such as the High-Luminosity Large Hadron Collider (HLLHC). At least 140 collisions will be produced each time two particle bunches meet at the heart of the
ATLAS and CMS detectors, compared to around 40 collisions at present. Consequently, significant challenges are to be expected in terms of data processing, reconstruction, and analysis. This project sets out to explore the development of unsupervised anomaly detection methods that do not rely on
prior knowledge of the underlying physics models.
With this in mind, the project exploits the theoretical and practical advantages of utilizing qutrits in Quantum Machine Learning (QML) models for the purpose of anomaly detection in high-energy physics data, with a particular focus on the context of experiments at CERN's Large Hadron Collider. The development of a quantum model based on qutrits is proposed, with a comparison with its qubit counterpart undertaken to evaluate its effectiveness in terms of accuracy, scalability and computational efficiency.
To achieve the desired objectives, a high-fidelity autoencoder structure has been utilized as a QAE reference, with CMS real jet data being employed to train the model. This model has been extrapolated to the qutrit state space, with the introduction of novel logic gates according to the parameters
of this state space.
References
[1] A. Bal, M. Klute, B. Maier, M. Oughton, E. Pezone, M. Spannowsky, "1 Particle - 1 Qubit: Particle
Physics Data Encoding for Quantum Machine Learning", (2025).
[2] S. Dogra, K. Dorai, Arvind, "Majorana representation, qutrit Hilbert space and NMR implementation of qutrit gates", Journal of Physics B: Atomic, Molecular and Optical Physics 51, 045505 (2018).
[3] S. K. Goyal, B. N. Simon, R. Singh, S. Simon, "Geometry of the generalized Bloch sphere for qutrits", J. Phys. A: Math. Theor. 49 165203 (2016)

Contribution type

Talk

Primary author(s) : CAROU LAIÑO, Miranda

Presenter(s) : CAROU LAIÑO, Miranda

Status: SUBMITTED

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

Abstract ID : **184**

Quantum reservoir computing using spin-boson system

Content

Quantum reservoir computing (QRC) is a quantum analog of classical reservoir computing (CRC), and is primarily used for classification or prediction of time-series. The reservoir is a complex quantum system that is dynamically driven by the inputs. A set of observables is measured in the output
layer and mapped to the target output using linear regression, while the reservoir's degrees of freedom remain unchanged. The main advantage over variational quantum algorithms is the absence of barren plateau or local minima. Spin-boson systems are an interesting choice for the reservoir. They couple spins to infinite-level harmonic oscillators, and can be easily simulated experimentally
using cavity- or circuit-QED setups. Compared to qubit-only reservoirs, the addition of a bosonic mode provides a significantly larger Hilbert space. On the other hand, coupling the spin with the bosonic mode results in non-Gaussian states, whereas a reservoir of linearly interacting bosonic modes gives rise to exclusively Gaussian states. Thus, spin-boson systems can realize a complex and rich dynamical mapping of the inputs, which is important for QRC. To function as a reservoir computer, the reservoir must satisfy a set of criteria, one of which is the ablity to retain the memory
of a few previous inputs. Assessing the reservoir's capacity to memorize past inputs is important in
order to understand its performance for prediction tasks.
The previous works lack a systematic benchmarking of the reservoir's memory in these systems, which is an important aspect of QRC. In our work, we employ the Jaynes-Cummings (JC) model and dispersive JC model as the reservoir. Using standard linear and nonlinear memory tasks, we quantify the reservoirs' memory, showing that they have better nonlinear memory than linear memory. This is in contrast to observations for qubit-only reservoirs. We also study how the memory capacity varies with different system parameters. Furthermore, we examine and benchmark the
reservoir's performance for complex chaotic Mackey-Glass time-series forecasting, which shows a
significantly good performance. Our work provides a clear illustration of QRC using spin-boson systems, and presents a comparison between JC and dispersive JC model in context of QRC for the first time.

Contribution type

Talk

Primary author(s) : DAS, Sreetama

Presenter(s) : DAS, Sreetama

Status: SUBMITTED

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

Abstract ID : **185**

An Adaptive Qubit Routing Algorithm for Ion-Trap QCCD Architectures

Content

As quantum computing progresses toward practical applications, optimizing compilation steps becomes increasingly important. Through this process, high-level quantum programs are translated into low-level instructions that can be executed on specific quantum hardware. A significant step in
this process is qubit routing, which ensures that logical qubits are physically moved or swapped into
place to satisfy the hardware's connectivity during gate operations. Standard routing approaches, even those adapted to specific quantum technologies, remain largely hardware-agnostic and algorithmindependent. This often leads to suboptimal circuit depth and reduced execution fidelity. In this
work, we introduce an adaptive qubit routing algorithm tailored for ion-trap Quantum ChargeCoupled Device (QCCD) architectures. Our approach combines structural insights from the quantum circuit with detailed knowledge of hardware topology and trap capacity. This co-optimization reduces routing overhead, improves gate scheduling through parallelism, and enhances overall circuit fidelity. By aligning compilation strategies with both algorithmic and architectural features, our method provides tangible performance benefits for current and near-term ion-trap quantum devices.

Contribution type

Talk

Primary author(s) : OVIDE GONZALEZ, Anabel

Presenter(s) : OVIDE GONZALEZ, Anabel

Status: SUBMITTED

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

Abstract ID : **186**

Using symmetries to enhance classical simulation

Content

Quantum computers are emerging technologies that promise substantial speed-ups for many computational tasks such as integer factoring, database searching, and quantum simulation. For quantum speed-ups to exist, classical simulation of quantum computations must be difficult. Studying classical simulation algorithms provides a deeper understanding of which quantum properties or resources enable this hardness. In turn, this improved understanding of the properties underpinning
quantum advantage allows us to leverage them to the fullest and design better quantum algorithms. Besides this foundational motivation for the study of classical simulation, other reasons of practical importance also exist. On the one hand, once fault-tolerant quantum devices start becoming available, we will want to have a way to certify that they are working properly. On the other hand, pushing the limit of what is possible with exclusively classical resources is essential to sharpening the boundary that defines the quantum advantage regime. As an example of the importance of this,
several quantum advantage claims have been disproved by the development of dedicated classical algorithms. Additionally, the better these algorithms, the more we will be able to do with classical (super)computers, thus allowing the study of increasingly complex quantum systems. This is of practical importance both in the academic context, as it arms us with powerful new tools to gain a deeper understanding of quantum systems and phenomena, but also in industry.
Here, we focus on improving the performance of a classical simulation algorithm whose cost is determined by a monotone function known as the stabilizer extent. This function assigns to a certain gate
a real number that quantifies how ‘resourceful’ that gate is for quantum computation. The stabilizer
extent is usually extremely hard to compute because it involves solving an optimization problem over a superexponentially large search space. We explore an innovative idea of using the symmetries of the resourceful gates to obtain superexponential reductions in the size of this search space. This allows us to compute the stabilizer extent for a wide variety of new gates up to 7 qubits (compared to the previous maximum of 2 qubits), unlocking the simulation of many important quantum circuits.

Contribution type

Talk

Primary author(s) : PERES, Filipa

Presenter(s) : PERES, Filipa

Status: SUBMITTED

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

Abstract ID : **188**

Certification of high-dimensional and multipartite entanglement with imperfect measurements

Content

Deciding whether an unknown quantum state is entangled is a central challenge in quantum information. The most common approach are entanglement witnesses, where one assumes the state to
be close to a known target and then finds suitable measurements that can reveal its entanglement. In principle, this allows for the detection of every entangled state. However, it requires the experimenter to flawlessly perform the stipulated measurements.
We move away from this idealized scenario to the more realistic situation in which measurement devices are not perfectly controlled, but operate with bounded inaccuracy. We formalize this through
an operational notion of inaccuracy that can be estimated directly in the laboratory and investigate
the impact of measurement errors on standard entanglement detection techniques. To demonstrate
the relevance of this approach, we show that small magnitudes of inaccuracy can significantly compromise several renowned entanglement witnesses.
We extend this analysis to the detection of high-dimensional and multipartite entanglement. To support our theoretical findings experimentally, we explicitly construct states that lead to a wrongful
detection of high Schmidt number or genuine multipartite entanglement when the inaccuracies in the measurements are not accounted for.

Contribution type

Talk

Primary author(s) : MORELLI, Simon

Presenter(s) : MORELLI, Simon

Status: SUBMITTED

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

Abstract ID : **189**

Thermodynamic approach to quantifying incompatible instruments

Content

We consider a thermodynamic framework to quantify instrument incompatibility via a resource theory subject to thermodynamic constraints. We use the minimal thermalization time needed to erase
incompatibility's signature to measure incompatibility. Unexpectedly, this time value is equivalent
to incompatibility advantage in a work extraction task. Hence, both thermalization time and extractable work can directly quantify instrument incompatibility.
Reference: C.-Y. Hsieh and S.-L. Chen, Phys. Rev. Lett. 133, 170401 (2024).

Contribution type

Talk

Primary author(s) : CHUNG-YUN , Hsieh

Presenter(s) : CHUNG-YUN , Hsieh

Status: SUBMITTED

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

Abstract ID : **191**

Chiral cat code: Enhanced error correction induced by higher-order nonlinearities

Content

We introduce a Schrödinger chiral cat qubit, a novel bosonic quantum code generalizing Kerr cat qubits that exploits higher-order nonlinearities. Compared to a standard Kerr cat, the chiral cat qubit allows additional correction of bit-flip errors within the Hilbert space of a single bosonic oscillator. Indeed, this code displays optical bistability, i.e., the simultaneous presence of multiple long-lived states. Two of them define the code space and two define an error space. Thanks to the chiral structure of the phase space of this system, the error space can be engineered to "capture" bit flip events in the code space (a bit-flip trap), without affecting the quantum information stored in the system. Therefore, it is possible to perform detection and correction of errors. We demonstrate how this topological effect can be particularly efficient in the presence of large dephasing. We
provide concrete examples of the performance of the code and show the possibility of applying quantum operations rapidly and efficiently. Beyond the interest in this single technological application,
our work demonstrates how the topology of phase space can enhance the performance of bosonic codes.

Contribution type

Talk

Primary author(s) : LABAY MORA, Adrià

Presenter(s) : LABAY MORA, Adrià

Status: SUBMITTED

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

Abstract ID : **192**

Potential renormalisation, Lamb shift and mean-force Gibbs state—to shift or not to shift?

Content

Often, the microscopic interaction mechanism of an open quantum system gives rise to a ‘counter term’ which renormalises the system Hamiltonian. Such term compensates for the distortion of the system’s potential due to the finite coupling to the environment. Even if the coupling is weak, the counter term is, in general, not negligible. Similarly, weak-coupling master equations feature a number of ‘Lamb-shift terms’ which, contrary to popular belief, cannot be neglected. Yet, the practice of vanishing both counter term and Lamb shift when dealing with master equations is almost
universal; and, surprisingly, it can yield better results. By accepting the conventional wisdom, one may approximate the dynamics more accurately and, importantly, the resulting master equation is
guaranteed to equilibrate to the correct steady state in the high-temperature limit. In this paper we discuss why is this the case. Specifically, we show that, if the potential distortion is small – but non-negligible – the counter term does not influence any dissipative processes to second order in the coupling. Furthermore, we show that, for large environmental cutoff, the Lamb-shift terms approximately cancel any coherent effects due to the counter term – this renders the combination of both contributions irrelevant in practice. We thus provide precise conditions under which the open-system folklore regarding Lamb shift and counter terms is rigorously justified.

Contribution type

Talk

Primary author(s) : CORREA MARICHAL, Luis Alberto

Presenter(s) : CORREA MARICHAL, Luis Alberto

Status: SUBMITTED

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

Abstract ID : **193**

Extended local ergotropies

Content

While for closed systems maximum quantum work extraction is given by the ergotropy, this question
was unclear in systems interacting with an environment. Recently, the concept of local ergotropy has been proposed [Salvia et al., Phys. Rev. A 107, 012405 (2023)] as the maximum extractable work
from the system-environment compound by applying a local unitary on the system.
We unfold formal weaknesses in the definition of local ergotropy, such as the fact that it is not guaranteed to be non-increasing in time. We then introduce the concept of extended local ergotropy [1] by exploiting the free-evolution of the system-environment compound. At variance with the local
ergotropy, the extended local ergotropy is greater by construction, is non-increasing in time, and activates the potential of work extraction in many cases. We provide examples based on the JaynesCummings model, presenting practical protocols and analytic results that serve as proof of principle
for the aforementioned advantages.
Then, we shift our attention to a quantum battery made up of many interacting sub-systems and study the maximum extractable work via concurrent local unitary operations on each subsystem. We call the resulting functional parallel ergotropy (PE) [2] and we devise methods to computing and bounding it using semidefinite programming. This paves the way for more realistic and feasible work-extraction protocols, if compared with those that require global operations on the whole system. Focusing on the bipartite case, we first observe that PE outperforms work extraction via egoistic strategies, in which the first agent A extracts locally on its part the maximum available work
and the second agent B, subsequently, extracts what is left on the other part. For the agents, this showcases the need of cooperating for an overall benefit. Finally, we show how with PE one can detect entanglement in the system.
[1] R. Castellano, D. Farina, V. Giovannetti, and A. Acin, “Extended local ergotropy”, Phys. Rev. Lett.
133, 150402 (2024).
[2] R. Castellano, R. Nery, K. Simonov, and D. Farina, “Parallel ergotropy: Maximum work extraction
via parallel local unitary operations”, Phys. Rev. A 111, 012212 (2025).

Contribution type

Talk

Primary author(s) : FARINA, Donato

Presenter(s) : FARINA, Donato

Status: SUBMITTED

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

Abstract ID : **194**

Unlocking Multi-Dimensional Integration with Quantum Adaptive Importance Sampling

Content

Perturbative Quantum Field Theory is central in performing accurate theoretical predictions of observables at high-energy colliders. Fundamental concepts in this framework, such as loop Feynman
diagrams and the phase-space, involve evaluating multidimensional integrals that are computationally intensive due to divergences and complex mathematical structures. To address these challenges
and improve the precision of such theoretical predictions, the standard approach relies on adaptive importance sampling. The most notable example is the VEGAS algorithm, which adaptively updates
a multidimensional grid. However, because the computational cost of handling each grid cell grows
exponentially with the number of the integral's dimensions, the model for the Probability Density Function (PDF) is simplified to a separable product of PDFs, factorized along each integration variable's axis.
In this work, we present a quantum algorithm that performs Quantum Adaptive Importance Sampling (QAIS). The algorithm has three elements. The first is encoding, where the integration domain
is discretized and mapped into a Parameterized Quantum Circuit (PQC). The second is state preparation, where through quantum generative modeling we optimize the PQC. The third is estimation, where the outcomes of direct measurement on the optimized PQC are processed by a dedicated statistical framework. This framework extends standard importance sampling to a quantum computational system. Its primary purpose is to produce an unbiased estimate of the integral, with a limited number of measurements.
By using the exponentially sized Hilbert space of PQCs, we manipulate the PDF over the grid in its
entirety. With adequate expressivity and entanglement, we effectively capture correlations among different integrand variables, thus bypassing the separable PDF assumption, as implemented in VEGAS. By optimizing the PQC, we adapt and ultimately load a PDF that approximates the integrand's
behavior. Direct sampling from it, allocates samples to the important regions, allowing a highly accurate integral estimation. As an application, we study benchmark integrals and loop Feynman integrals, and compare the precision of VEGAS's best grid against that of the quantum-generated proposal PDF, as a function of the number of samples.
References
K. Pyretzidis, J.J. Martínez de Lejarza and G. Rodrigo, Unlocking Multi-Dimensional Integration with
Quantum Adaptive Importance Sampling, e-Print: 2506.19965 [quant-ph]

Contribution type

Talk

Primary author(s) : PYRETZIDIS, Konstantinos

Presenter(s) : PYRETZIDIS, Konstantinos

Status: SUBMITTED

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

Abstract ID : **195**

Quantum recurrent neural networks for multivariate time series prediction

Content

Classical models for time series forecasting, despite their success, often face challenges related to training, generalization, energy consumption and interpretability. Unconventional computing paradigms, such as quantum computing, offer a promising avenue to address these limitations. Quantum Recurrent Neural Networks (QRNN) emerge as a powerful approach for multivariate time series
prediction.
We study a variational QRNN model featuring a quantum circuit with mid-circuit measurements and
reset, applied iteratively for each time series step. A subset of qubits undergoes these operations, while others serve as quantum memory. We derived the analytical formulation of the operators governing the circuit's state evolution. This formulation enabled the development of a specific purpose
emulator for the QRNN, more efficient than a general-purpose quantum circuit emulator. Moreover,
we derived the parameter shift rule for computing the first- and second-order partial derivatives of
measurement results with respect to the variational parameters in the quantum circuit.
In our work [1], the QRNN involves a hardware-efficient ansatz for the state evolution and uses expectation values for outputs generation at each time series step. We benchmark the model against four datasets of varying complexities, including both numerical and analytical gradients, as well as
noisy expectation values due to finite number of shots (sampling noise). The results show how the QRNN, trained with both gradient types, accurately predicts future values by capturing non-trivial patterns in input series. Its prediction capacity is comparable to well-known classical approaches RNN, LSTM and GRU with similar number of trainable parameters, as well as quantum reservoir computing with weak measurements protocols, often exhibiting improved generalization. Consequently, the QRNN is a viable and competitive addition to the toolkit of algorithms for multivariate time series prediction.
[1] Viqueira, J. D., Faílde, D., Juane, M. M., Gómez, A., & Mera, D. (2025). Density matrix emulation of quantum recurrent neural networks for multivariate time series prediction. Machine Learning: Science and Technology, 6(1), 015023. https://doi.org/10.1088/2632-2153/ad9431

Contribution type

Talk

Primary author(s) : VIQUEIRA CAO, José Daniel

Presenter(s) : VIQUEIRA CAO, José Daniel

Status: SUBMITTED

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

Abstract ID : **196**

Entanglement Generation in Parallel NV Centers for Enhanced Quantum Sensing

Content

Entanglement is a key quantum feature that enables quantum sensors to improve their sensitivity [1] up to the Heisenberg limit. In the NV-center platform, the Heisenberg limit can only be achieved
when the axes of the NV centers are parallel. Nevertheless, parallel NV centers are spectrally indistinguishable and no mechanisms to directly prepare Heisenberg-limit-grade entanglement in such
configurations are known to date. In this work we propose for the first time a viable mechanism to prepare entangled states in the double quantum transition of two dipolarly coupled NV centers whose axes are parallel without populating intermediate states. Our approach is based on the NV effective Raman coupling (NV-ERC) protocol [2-4] and makes use of global addressing of both NV centers with a single monochromatic microwave pulse. Supported by an adiabatic elimination analysis, several mechanisms for the preparation of different entangled states are identified which avoid
participation of intermediate states in all cases, thus limiting the impact of additional unwanted noise
sources. All proposed states belong to the double quantum transition, sensitive to either transverse electric fields or longitudinal magnetic fields, all with a fourfold improved sensitivity compared to conventional single NV settings.

[1] T. Xie, Z. Zhao, X. Kong, W. Ma, M. Wang, X. Ye, P. Yu, Z. Yang, S. Xu, P. Wang, Y. Wang, F. Shi, and J. Du, Beating the standard quantum limit under ambient conditions with solid-state spins, Science Advances 7, eabg9204 (2021).
[2] Cerrillo, J., Oviedo Casado, S., Prior, J.: Low field nano-nmr via three-level system control. Phys.
Rev. Lett. 126, 220402 (2021).
[3] 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).
[4] 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).
[5] Morillas-Rozas, M., López-García, A., Cerrillo, J.: Entanglement Generation on the Double Quantum Transition of NV Ground State Via Globally Addressing Microwave Pulse. arXiv: 2501.18244.

Contribution type

Talk

Primary author(s) : MORILLAS-ROZAS, Marcel

Presenter(s) : MORILLAS-ROZAS, Marcel

Status: SUBMITTED

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

Abstract ID : **197**

NetQMPI: programming Distributed Quantum Applications over NetQASM using an MPI-like model

Content

Distributed quantum computing (DQC) offers a scalable path forward by interconnecting multiple quantum processing units (QPUs) through quantum networks. This enables modular architectures, where several smaller quantum devices collaborate as a single logical system. However, programming such systems remains challenging due to the need to orchestrate entanglement distribution, synchronize classical control, and respect quantum mechanical constraints. This work introduces NetQMPI, a Python library that provides a message-passing interface for distributed quantum applications, inspired by the classical MPI model but tailored to quantum scenarios. Built on top of NetQASM and aligned with the NetQIR abstraction stack, NetQMPI exposes quantum-safe primitives such as qsend, qrecv, qscatter, and qgather, enabling modular and architecture-independent programming of distributed quantum workflows. By leveraging NetQASM, NetQMPI is directly compatible with leading quantum network simulators like NetSquid and SimulaQron. The library is open source and designed to support ongoing research in quantum network programming and distributed quantum algorithm design.

Contribution type

Talk

Primary author(s) : CARDAMA SANTIAGO, Francisco Javier

Presenter(s) : CARDAMA SANTIAGO, Francisco Javier

Status: SUBMITTED

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

Abstract ID : **198**

Benchmarking Quantum Simulators for Shor's Algorithm in SCAYLE: A Comparative Study with Classical Systems

Content

Quantum computing represents a major shift in cryptography, with the potential to solve certain problems exponentially faster than classical computers. This challenges widely used cryptographic schemes based on the hardness of integer factorization, making the study of quantum algorithms and hardware a critical area of research for digital security.

Integer factorization is fundamental in modern cryptography, underpinning protocols used in secure communications and digital authentication. However, classical methods become increasingly inefficient when factoring large semiprimes. Shor's algorithm, a quantum algorithm for integer factorization, illustrates the need for quantum computers capable of executing such processes efficiently
and with minimal error.

However, the hardware of current quantum devices is limited by short coherence times and gate inaccuracies. As a result, quantum simulators have emerged as essential tools to test algorithms and evaluate resource requirements without relying on fully functional quantum hardware. These simulators allow researchers to explore algorithmic behavior and scalability, particularly in terms of circuit depth and qubit usage.

This study evaluates the performance of two quantum simulators available at SCAYLE (Supercomputación Castilla y León) through the implementation of Shor's algorithm. To ensure a comprehensive comparison, high-performance classical systems are also included. Tests were conducted on classical machines with 1 TB and 2 TB of RAM, and on two quantum emulators hosted on the Caléndula supercomputer: the Fujitsu FX700 (mpiQulacs-based, 8 nodes, 48 cores per node, 33-qubit
emulation) and the Eviden Qaptiva 802 (myQLM-based, 112 cores, 2 TB RAM, 30-qubit emulation).

The experiments compare two key metrics: circuit depth scalability and performance relative to classical factorization methods. Results highlight current limitations of both quantum simulation and classical computation, while also providing insights into the resource demands of quantum algorithms.

In summary, although current quantum simulators cannot yet fully replicate large-scale quantum computation, they offer a valuable testing and optimizing platform for quantum algorithms. This work contributes to ongoing efforts to understand the feasibility of quantum cryptography approaches
under realistic infrastructure constraints.

Contribution type

Talk

Primary author(s) : MERINO BAJO, Santiago

Presenter(s) : MERINO BAJO, Santiago

Status: SUBMITTED

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

Abstract ID : **199**

Connecting time crystals to many-body protection

Content

Time crystals are phases of matter that spontaneously break the time-translational symmetry, and are characterized by time-periodic behavior that is robust against all types of fluctuations, even quantum noise. They are temporal counterparts of ordinary spatial crystals, exhibiting analogous properties but in time. Since it is not yet clear if time crystals exist in equilibrium systems, attention
has shifted to out-of-equilibrium situations, such as driven-dissipative systems. This has motivated
the search for so-called dissipative time crystals, where time-crystallinity emerges as a robust asymptotic state of the open-system dynamics.
Within this context, some people have proposed that small systems such as a single quantum Van der Pol (VdP) oscillator can be a dissipative time crystal. However, in this work, we prove that small
systems like that are not robust against dephasing (a realistic source of noise in physical systems), and then we would not characterize them as time-crystalline phases of matter, but rather as mathematical analogs which nevertheless are still very interesting as toy models. In particular, we study numerically the dissipative gap, which should be zero for true time-crystalline order. In the absence
of dephasing, we show that the gap goes to zero linearly with the number of excitations, while in its
presence the gap saturates to a value close to the dephasing rate.
Following this, we conjecture that extended systems are required to achieve true time-crystalline order, in particular because they can use many-body protection against local dephasing. In order to
test this conjecture, we analyze a well-known spin model with all-to-all interactions, which shows time-crystalline behavior. Our simulations then reveal that the system is not robust against dephasing noise acting on all spins collectively, but also find evidence that they might be robust against
local dephasing.
This study aims to support the view that in order to spontaneously break continuous time-translational symmetry, many-body physics must come into place, and hence small-sized systems lack the structure to support this behaviour

Contribution type

Talk

Primary author(s) : KASNETSI, Paraskevi

Presenter(s) : KASNETSI, Paraskevi

Status: SUBMITTED

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

Abstract ID : **200**

Learning from the unknown: Universal Quantum State Discrimination

Content

Universal quantum protocols aim to distinguish quantum states without prior knowledge of their specific form. The question of whether such protocols can be designed to perform optimally on average—independently of the input—arises naturally in quantum information, particularly in scenarios where full state information is unavailable.

We study universal discrimination tasks involving pure states arranged in symmetric tensor product structures. These settings include primitive tasks such as quantum edge detection, anomaly detection, and programmable machines, all formulated from a universal perspective. We show that
the inherent symmetries in these ensembles impose strong representation-theoretic constraints on the form of any optimal measurement. In particular, Schur–Weyl duality emerges naturally as the mathematical framework underlying these protocols. This structure also brings a computational advantage: the states decompose into block-diagonal forms, significantly reducing the complexity of
associated optimization problems, as it only accounts for the relevant available information.

Our analysis identifies the structural requirements for universal measurements to be optimal. We show how such measurements can be constructed systematically using tools from representation theory, and how their performance can be characterized analytically, offering a benchmark on the ultimate limits of their success probability. These constructions are broadly applicable and require no prior knowledge of the specific states being discriminated.

A key observation across all scenarios is a common behavior: as the number of unknown components in the hypotheses increases, the performance of universal protocols improves—even though the number of hypotheses grows in parallel, making the discrimination task more difficult. This effect can be interpreted as a learning phenomenon, and highlights how the presence of more unknown quantum states can counterintuitively make the discrimination task easier.

These results contribute to the understanding of symmetry-constrained quantum protocols and provide a general algebraic framework for analyzing universal discrimination problems.

Contribution type

Talk

Primary author(s) : LLORENS, Santiago

Presenter(s) : LLORENS, Santiago

Status: SUBMITTED

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

Abstract ID : **201**

Efficient and robust probe of spectral properties via super-resolution quantum simulation

Content

Quantum Simulation is a key tool to understand complex phenomena in fields such as Condensed Matter and High-energy Physics. Moreover, it is expected to drive potential applications in Material
Science and Quantum Chemistry crucially in the form of Quantum Advantage. One important task
for Quantum Simulation is to probe the energy spectrum of a given system as well as to characterize
state properties. However, NISQ-based algorithms often rely on a precise preparation of the relevant
states.
To circumvent this issue, the recently emerging Shadow Spectroscopy estimates energy differences from an initial state which only overlaps with the target eigenstates. This method exploits the fact that expectation values of time-evolved observables oscillate with a combination of frequencies that
exactly correspond to eigenenergy differences. These time series are reconstructed from the Classical Shadows of the time-evolved initial state. Given that time evolution is an efficient task for a quantum simulator, Quantum Advantage is potentially expected. A crucial feature is the direct obtention of energy differences, thus avoiding the noisier approach of firstly estimating individual energies and
then substracting them.While reconstructing No observables requires O(log(2No)) shots per time step, we present an improved method which also delivers the target energy difference but operates with just one “sweet”
observable, thus reducing shot complexity and not requiring shadows. This observable guarantees that the peak intensity of the target frequency in the Fourier spectrum is always non-zero and the largest one.This makes it straightforward to find the said frequency by just reading that of the tallest
peak.On the contrary, Shadow Spectroscopy needs to sample a huge set of observables to increase the signal-to-noise ratio yet an easy peak identification is not guaranteed. We provide clever gadgets
to recover both eigenenergies Ei and eigenenergy differences Ei − Ej -even between two different Hamiltonians- and not just |Ei − Ej | as delivered by Shadow Spectroscopy.
Moreover,we propose the use of super-resolution and energy filtering methods for a more accurate and robust frequency extraction, and provide numerical evidence in small-sized systems.All in all, we expect that our method will help to enlarge the toolbox for probing spectral properties.

Contribution type

Talk

Primary author(s) : ESCALERA MORENO, Luis

Presenter(s) : ESCALERA MORENO, Luis

Status: SUBMITTED

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

Abstract ID : **202**

Symmetries and incompatibility in global multiparameter quantum metrology

Content

Harnessing symmetry and geometry has recently emerged as a powerful strategy to enhance quantum metrology, especially when combined with Bayesian principles. These ideas have led to substantial gains in precision for finite samples and physically meaningful priors, as demonstrated in a
series of cold atom experiments. Yet, such advances have been mostly confined to single-parameter estimation, leaving the richer multiparameter landscape largely unexplored. In this talk, I will review key experimental insights and propose a Bayesian framework for multiparameter quantum estimation that systematically incorporates symmetry. I will discuss bounds on the true multiparameter optimum and identify a notion of estimation incompatibility, offering both theoretical insights and practical tools for the next generation of quantum sensors. Relevant developments include
[arXiv:2502.14817, 2410.10615, 2402.16410, 2204.11816, 1906.04123].

Contribution type

Talk

Primary author(s) : RUBIO JIMÉNEZ, Jesús

Presenter(s) : RUBIO JIMÉNEZ, Jesús

Status: SUBMITTED

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

Abstract ID : **203**

Towards a Fundamental Finite-Time Correction of Landauer's Principle

Content

According to the third law of thermodynamics, perfect cooling cannot be achieved with finite resources. As a consequence, one expects a finite-time correction to Landauer's bound for information erasure. However, whether this correction can be made arbitrarily small for a fixed erasure time—or
whether it has a nonzero, fundamental lower bound—remains an open question. In this work, we review a collection of results that pave the way toward establishing such a fundamental finite-time correction-or the lack thereof. We begin by surveying insights from open quantum system dynamics,
which consistently show that any truly fundamental correction must be derived from exact unitary dynamics, beyond the Lindblad regime. We then turn to recent results (Quantum 7, 1161 (2023))
that compute this correction for a specific model using exact out-of-equilibrium dynamics. These findings reveal not only the structure of the correction, but also highlight the role of the Planckian time scale, \tau_{Pl} = \hbar/k_BT in the bound. Building on a recent proof of the Planckian bound conjecture (arXiv:2506.19188 (2025)), we conjecture a concrete form for the fundamental finite-time
Landauer bound. Finally, we discuss how collective effects in finite-time thermodynamics can significantly suppress dissipation during erasure (Phys. Rev. Lett. 131, 210401 (2023)), a phenomenon that appears to challenge the existence of a fundamental correction.

Contribution type

Talk

Primary author(s) : ROLANDI, Alberto

Presenter(s) : ROLANDI, Alberto

Status: SUBMITTED

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

Abstract ID : **204**

Quantum Hamiltonian simulation using an ancilla

Content

Simulation algorithms are essential tools in physics for modeling and understanding the underlying
mechanisms of nature. In principle, classical computers can be used to replicate physical phenomena. However, their computational limitations prevent them from efficiently simulating quantum systems. This challenge motivates the development of quantum simulation algorithms.
In this work, we explore quantum generative adversarial networks (QGANs) as an alternative approach to quantum simulation. A QGAN consists of two quantum circuits: a generator and a discriminator. The generator is defined by a unitary operation built from single- and two-qubit Pauli
rotation gates forming a universal gate set. The jth gate in Ui
is parameterized by a rotation angle
$\theta_{i,j}$. The goal of the generator is to learn an unknown quantum state σ by adjusting its parameters to produce an approximate state ρ. The discriminator receives either ρ or σ and performs quantum measurements to distinguish between them. It is parameterized by two quantum states, ψ and ϕ, and is trained to maximize the Quantum Wasserstein distance between ρ and σ.
However, during training, the learning process can stagnate at suboptimal fidelities—a phenomenon we refer to as a learning plateau. To address this, we modify the QGAN architecture and propose two
intervention strategies. The first stratergy, passive intervention, involves randomizing the parameters of both the generator and the discriminator. We also introduce an active intervention approach,
which adds an ancilla qubit to the generator. This method expands the parameter space and proves more effective at overcoming learning plateaus.
We evaluate the performance of both strategies by simulating target systems of 2, 3, 4, and 5 qubits and varying the depth of the generator circuit from 3 to 5 layers. Our results demonstrate that modifying the QGAN architecture with tailored intervention techniques enhances its flexibility and
effectiveness in learning a wide range of target states.

Contribution type

Talk

Primary author(s) : SASIDHARAN VASANTHAKUMARI, Hari krishnan

Presenter(s) : SASIDHARAN VASANTHAKUMARI, Hari krishnan

Status: SUBMITTED

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

Abstract ID : **205**

Quantum batteries and quantum phase transitions

Content

Advances in quantum technologies have intensified interest in the energetics of quantum systems; as a result, quantum thermodynamics has become central to the design of novel quantum devices. Within this field, quantum batteries—quantum systems that store and release energy on demand—have gained significant attention. Their relevance is threefold: they address fundamental questions
about quantum energy exchange, they can outperform classical batteries in charging power, and they may offer advantages in energy and time efficiency within complex quantum devices.
In this realm, we introduce a quench-based framework for charging quantum batteries, modeled as
spin chains whose Hamiltonian parameters are driven across quantum critical points. Our aim is to
determine how the structure of the quantum phase diagram affects charging in the thermodynamic limit.
First, we identify three charging timescales: (i) a short-time regime governed by single-dimer dynamics, (ii) a long-time regime reflecting finite-size recurrences, and (iii) a thermodynamic-limit regime
where the stored energy becomes largely independent of the quench duration [1].
Building on this, we derive an analytical expression for the energy injected by double sudden quenches
in general 2x2 free-fermion Hamiltonians initialized in thermal states. Applying this to the transversefield Ising, XY, cluster-Ising, and long-range SSH models, we reveal universal non-analytic kinks in
the stored energy at the charging Hamiltonian's critical points—persistent even at finite temperature
and in the presence of long-range interactions. Additionally, when starting from classical points, we
observe broad "plateaus" of stored energy, largely independent of system parameters, offering experimentally accessible regimes of robust charging [2].
Finally, to test noise resilience, we simulate noisy quenches with variable speed in a transversefield
Ising chain under Ornstein–Uhlenbeck noise. From the ensemble-averaged density matrix evolution,
we extract ergotropy (maximal extractable work via unitary operations), stored energy and efficiency
(their ratio).
Overall, our framework brings new depth to the study of many site quantum batteries, demonstrating
both how internal parameter drives across phase diagrams enable robust charging in the thermodynamic limit and how environmental noise shapes their performance.
[1] R.Grazi et al., Phys. Rev. Lett. 133, 197001 (2024)
[2] R.Grazi et al., Chaos, Solitons and Fractals 196, 116383 (2025)

Contribution type

Talk

Primary author(s) : GRAZI, Riccardo

Presenter(s) : GRAZI, Riccardo

Status: SUBMITTED

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

Abstract ID : **206**

Perovskites Nanocrystals and QED approaches for single photon emitters.

Content

Lead halide nanocrystals are established as low-cost nanostructures for realizing perovskite-based single-photon emitters. In 2015, Park and colleagues [1] demonstrated the first perovskite-based single-photon source operating at room temperature (RT) using all-inorganic CsPbI3 quantum dots (QDs). Since then, quantum light emission has been observed in various perovskite nanocrystals (PNCs) at both RT and cryogenic temperatures. Despite the remarkable features of PNCs, the use of PNCs for the incoming quantum technologies with light is restricted by their photostability and their challenging integration into photonics platforms. In this study, we utilized cryogenic μ-photoluminescence (μ-PL), and μ-Time-Resolved Photoluminescence (μ-TRPL) spectroscopy to investigate the spectral stability of single colloidal cesium lead halide PNCs with different capping ligands [2]. Notably, we have found that using a Zwitterionic (ZW) ligand significantly reduces the
blinking effect and spectral diffusion for the cesium lead bromide PNCs, enhancing their spectral stability and reducing their μ-PL linewidths (~125-140 μeV). Additionally, strong dephasing at room temperature necessitates optimized QED approaches. We analyzed photon funneling in $CsPbBr_3$ NCs embedded in open planoconvex microcavities with different modal volumes [3]. A generalized
Purcell factor of F = 30 is observed. These insights guide future cavity designs for efficient PNC-based
single photon sources.

[1] Park, Young-Shin, Shaojun Guo, Nikolay S. Makarov, and Victor I. Klimov. Room temperature single-photon emission from individual perovskite quantum dots. ACS nano 9, 10386 (2015)
[2] S. Gorji, H. Pashaei Adl, A. F. Gualdrón-Reyes, et al. Enhanced Optical Stability of All Inorganic Perovskite Nanocrystals for Single Photon Emission. Adv. Optical Mater 13, 2403441 (2025).
[3] Warren Smith, Sergi De Maria Garcia, Setatira Gorji et al. Generalised Purcell Factor Enhancement of Perovskite Nanocrystals in an Open Cavity at Room Temperature. Appl. Phys. Lett (In review – 2025).

Contribution type

Talk

Primary author(s) : MUÑOZ MATUTANO, Guillermo

Presenter(s) : MUÑOZ MATUTANO, Guillermo

Status: SUBMITTED

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

Abstract ID : **207**

Ultrafast exciton fluid flow in an atomically thin MoS2 semiconductor

Content

Excitons (coupled electron–hole pairs) in semiconductors can form collective states that sometimes exhibit spectacular nonlinear properties, such as superfluidity and/or superradiance, among some others1,2. Here, we show experimental evidence of a collective state of short-lived excitons in a direct-bandgap, atomically thin MoS2 semiconductor whose propagation resembles that of a classical liquid3. This is suggested by the nearly uniform photoluminescence through the MoS2 monolayer
regardless of crystallographic defects and geometric constraints. The exciton fluid flows over ultralong distances (at least 60 μm) (see Fig. 1(A)-(C)) at a speed of ~1.8 × 10^7 m/s (~6% the speed of light).
The collective phase emerges above a critical laser power, in the absence of free charges and below a critical temperature (usually Tc ≈ 150 K, see Fig. 1(D)) approaching room temperature in hexagonalboron-nitride-encapsulated devices. Our theoretical simulations suggest that momentum is conserved and local equilibrium is achieved among excitons; both these features are compatible with
a fluid dynamics description of the exciton transport. Our findings have implications for ultrafast exciton-mediated optical switches, exciton-valley Hall devices and on-chip exciton circuitry.
References
1 Keldysh, L. V. & N., K. A. “Collective properties of excitons in semiconductors”. JETP 27, 978 (1968).
[2] High, A. A. et al. “Spontaneous coherence in a cold exciton gas”. Nature 483, 584 (2012).
[3] [A. Granados del Águila et al., “Ultrafast exciton fluid flow in an atomically-thin MoS2 semiconductor”. Nat. Nanotechnol. 18, 1012 (2023)

Contribution type

Talk

Primary author(s) : GRANADOS DEL AGUILA, Andres

Presenter(s) : GRANADOS DEL AGUILA, Andres

Status: SUBMITTED

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

Abstract ID : **208**

Characterising quantum measurement through environmental stochastic entropy production in a two spin 1/2 system

Content

Quantum state diffusion is a framework describing measurement as the continuous and gradual collapse of a quantum system to an eigenstate as a result of its interaction with an environment [1, 2].
Continuous stochastic quantum trajectories may be generated using such a framework from which quantities such as the environmental stochastic entropy production associated with performing a specific measurement may be found [3]. We consider a system of two spin 1/2 particles undergoing measurement of the z-components of spin of the individual particles or the combination. We compare the average rates of stochastic environmental entropy production according to the type of
measurement performed, the eigenstate to which the system has collapsed, and the initial state of the
system before measurement. The asymptotic average rate of stochastic environmental entropy production associated with collapse to an eigenstate of total Sz differs according to these circumstances.
The stochastic environmental entropy production therefore carries a memory of the initial state of the system and offers an additional avenue for characterising quantum measurement. [1] S. M. Walls, J. M. Schachter, H. Qian, and I. J. Ford, Stochastic quantum trajectories demonstrate
the quantum Zeno effect in open spin 1/2, spin 1 and spin 3/2 systems, Journal of Physics A: Mathematical and Theoretical 57, 175301 (2024).
[2] S. M. Walls and I. J. Ford, Memory effects in a sequence of measurements of noncommuting observables, Physical Review
A 110, 032432 (2024).
[3] C. L. Clarke and I. J. Ford, Stochastic Entropy Production Associated with Quantum Measurement in a Framework of
Markovian Quantum State Diffusion, Entropy 26, 1024 (2024).

Contribution type

Talk

Primary author(s) : WALLS, Sophia

Presenter(s) : WALLS, Sophia

Status: SUBMITTED

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

Abstract ID : **209**

Quantum Advantage Today via Iterative Learning and Composition of Hardwares

Content

We introduce a framework that merges cutting-edge quantum optimization algorithms with a new paradigm that sequentially combines quantum platforms to tackle higher-order unconstrained binary optimization (HUBO) problems. Our method is based on the bias-field digitized counterdiabatic
quantum optimization (BF-DCQO) algorithm [1,2], recently tested on 156-qubit IBM superconducting qubits and 36-qubit IonQ trapped ions. Applied to industrially relevant HUBO problems (e.g., MAX k-SAT and protein folding), BF-DCQO outperforms well-known quantum and classical methods [3,4]. To overcome the limitations of individual platforms and harness their complementary strengths, we propose sequential quantum computing (SQC) [5], which connects heterogeneous quantum by using the outcomes of one device to initialize a subsequent one. We experimentally implement SQC by connecting D-Wave quantum annealers with IBM hardware, achieving significant improvements in quality and efficiency for HUBO problems. Our findings establish BF-DCQO and SQC as complementary tools for scalable and large-scale quantum optimization, among other applications, with current and near-term hardware.
[1] Cadavid et al. Bias-field digitized counterdiabatic quantum optimization. Phys. Rev. Research 7,
L022010 (2025)
[2] Romero et al. Bias-Field Digitized CounterdiabaticQuantum Algorithm for Higher-Order Binary
Optimization. arXiv:2409.04477 (2024)
[3] Simen et al. Branch-and-bound digitized counterdiabatic quantum optimization. arXiv:2504.15367 (2025)
[4] Chandarana et al. RuntimeQuantum Advantage with DigitalQuantum Optimization. arXiv:2505.08663 (2025)
[5] Romero et al. Sequential Quantum Computing. arXiv:2506.20655 (2025)

Contribution type

Talk

Primary author(s) : ROMERO, Sebastián V.

Presenter(s) : ROMERO, Sebastián V.

Status: SUBMITTED

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

Abstract ID : **210**

Harnessing strong system-bath coupling in quantum thermal machines: From synchronization to enhanced performance and precision

Content

Common intuition suggests that strong coupling to a thermal bath typically degrades the performance of a quantum thermal machine. Here, we show that, contrary to this expectation, a quantum thermal machine can leverage strong system-bath coupling to improve performance and precision. We consider a microscopic model where the working medium comprises two non-interacting quantum harmonic oscillators. First, we show that the presence of a common thermal bath—effectively mediating non-trivial correlations between the quantum harmonic oscillators—can outperform, in terms of both power and efficiency, an analogous configuration of two independent engines operating in parallel. This advantage is particularly pronounced in the strong-coupling regime, where overdamping suppresses power output in independent engines [1]. Furthermore, we reveal a close connection between the strong-coupling regime and the synchronization of the quantum harmonic oscillators. In this regime, the non-Markovian nature of a second thermal bath—coupled through periodic drives that break time-reversal symmetry—enables precise, finite local work currents that violate classical thermodynamic uncertainty relations [2].
[1] AVS Quantum Sci. 6, 025001 (2024)
[2] Quantum Sci. Technol. 9, 045032 (2024)

Contribution type

Talk

Primary author(s) : RAZZOLI, Luca

Presenter(s) : RAZZOLI, Luca

Status: SUBMITTED

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

Abstract ID : **211**

Optimal quantum transport on a ring via locally monitored chiral quantum walks

Content

In purely coherent transport on finite networks, destructive interference can significantly suppress transfer probabilities, which can only reach high values through careful fine-tuning of the evolution time or tailored initial-state preparations. We address this issue by investigating excitation transfer on a ring, modeling it as a locally monitored continuous-time chiral quantum walk. Chirality, introduced through time-reversal symmetry breaking, imparts a directional bias to the coherent dynamics and can lift dark states. Local monitoring, implemented via stroboscopic projective measurements at the target site, provides a practical detection protocol without requiring fine-tuning of the evolution time. By analyzing the interplay between chirality and measurement frequency, we identify optimal conditions for maximizing the asymptotic detection probability. The optimization of this transfer protocol relies on the spectral properties of the Perron-Frobenius operator, which capture the asymptotic non-unitary dynamics, and on the analysis of dark states. Our approach offers a general framework for enhancing quantum transport in monitored systems.

Contribution type

Talk

Primary author(s) : FINOCCHIARO, Sara

Presenter(s) : FINOCCHIARO, Sara

Status: SUBMITTED

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

Abstract ID : **212**

Local energy assignment for two interacting quantum thermal reservoirs

Content

Understanding how to assign internal energy, heat, and work in quantum systems beyond weak coupling remains a central problem in quantum thermodynamics, particularly as the difference between competing definitions becomes increasingly relevant. In this work, we identify two (different) common sets of definitions for first law quantities that are used in the literature to describe the
thermodynamics of quantum systems coupled to thermal environments. Both are conceptually nonsymmetric, treating one part of the bipartition (the "system") differently from the other (the "bath").
We analyze these in a setting where such roles are not easily assigned — two large (but finite) sets of thermal harmonic oscillators interacting with each other. We further compare them with a third set of definitions based on a local, conceptually symmetric open-system approach ("minimal dissipation") and discuss their quantitative and structural differences. In particular, we observe that all
three sets of definitions differ substantially even in the regime where the coupling is smaller than the detuning, and that the minimal dissipation approach features distinct work peaks (absent in the
other definitions) that increase with coupling strength.

Contribution type

Talk

Primary author(s) : COLLA, Alessandra

Presenter(s) : COLLA, Alessandra

Status: SUBMITTED

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

Abstract ID : **214**

Exploring a star lattice Hamiltonian with Neural Network Quantum States

Content

We present a study of a particular S=1/2 Heisenberg model on a two-dimensional star network[1] using Neural-Network Quantum States (NNQS)[2]. This model serves as a platform to explore various spin phases dictated by the interplay between two coupling constants, one ferromagnetic and the other antiferromagnetic. Consequently, the system offers an ideal scenario for investigating a quantum phase transition between an effective spin 3/2 phase when the ferromagnetic coupling dominates and a phase characterized by the formation of valence bond states in the strong antiferromagnetic limit. The use of NNQS enables the examination of these effects in significantly larger systems compared to exact diagonalization. This work marks a promising advancement in the study of quantum phase transitions in large and complex spin systems.

Contribution type

Talk

Primary author(s) : FERRI CORTES, Mar

Presenter(s) : FERRI CORTES, Mar

Status: SUBMITTED

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

Abstract ID : **215**

Quantum metrology through spectral measurements in quantum optics

Content

Quantum optical systems can emit light with very complex spectral properties. For instance, the emergence of dressed states from coherently driven quantum emitters, hybridized excitonic states or hybrid light-matter states (polaritons) in cavity QED translate into rich fluorescence spectra with
multiple peaks that reflect the complex structure of eigenstates. These spectra exhibit equally complex dependences with the parameters that govern the dynamics of the system, and therefore offer the opportunity to improve the inference of unknown parameters by frequency-filtering the emitted
signal.
Here, we explore this idea in quantum optical systems consisting of coherently driven quantum emitters in dissipative scenarios. Specifically, in Ref. [1], we focus on the estimation of the interemitter distance between two nonidentical interacting quantum emitters driven by a coherent field
by measuring the fluorescence spectrum. We identify, by means of the Fisher information [2], that the two-photon resonance (i.e., when the laser frequency is at half of the energy of the doubly excited
state) and the onset of the two-photon saturation regime (i.e., when the two-photon dressing effects
begin to be resolved in the spectrum) are the most sensitive points for distance estimation.
It is known that hybridized light-matter systems, e.g., a strongly driven two-level system [3], give complex correlations in frequency space. Following this idea, we discuss the role of quantum correlations and quantify their impact on the precision by which unknown atomic parameters can be estimated, assessing the potential of frequency-resolved correlation measurements for the task of parameter estimation in driven-dissipative quantum optical systems.
[1] A. Vivas-Viaña and C. Sánchez Muñoz, Two-photon resonance fluorescence of two interacting nonidentical quantum emitters, Phys. Rev. Research 3, 033136 (2021).
[2] M. G. Paris, Quantum estimation for quantum technology, Int. J. Quantum Inf. 07, 125 (2009).
[3] C. Sánchez Muñoz, E. del Valle, C. Tejedor, and F. P. Laussy, Violation of classical inequalities by
photon frequency filtering, Phys. Rev. A 90, 052111 (2014).

Contribution type

Talk

Primary author(s) : VIVAS-VIAÑA, Alejandro

Presenter(s) : VIVAS-VIAÑA, Alejandro

Status: SUBMITTED

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