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BOOK OF ABSTRACTS

Quantum thermodynamic insights and their use for magnetism modelling and cold atom thermometry

Janet Anders (Universities of Exeter and Potsdam, UK and Germany)

Abstract. I will discuss two recent examples where the insights of quantum thermodynamic theory have led to improved understanding and advanced techniques in other subfields of physics. First, in magnetism, the damped dynamics of spins is commonly modelled classically with the so-called LLG equation. Instead, we use an open quantum system approach to this problem [1]. It allows understanding how quantum statistics and memory kernels that arise from the bath, impact on a material's magnetisation properties. The utility of this approach is demonstrated by predicting the equilibrium state's magnetisation of a material (e.g. nickel) as a function of temperature [2]. Our approach also predicts the occurrence of multiple nutation peaks in the Fourier spectrum of ultrafast magnetisation dynamics. Moreover for an experimentally measured cobalt film, our theory shows excellent quantitative agreement with observations [3]. Second, in cold atom experiments, estimation protocols commonly use mean square errors and fixed control parameters. Instead, we propose the use of global quantum estimation theory [4]. It incorporates symmetry and Bayesian principles to identify optimal control parameters, and is most relevant for small data sets. Application to a cold atom experiment leads to a five-fold precision enhancement in atom number estimation when using a symmetry-informed, adaptive Bayesian strategy in comparison to standard strategies [5].

[1] Quantum Brownian Motion for Magnets, New J. Phys. 24, 033020 (2022).
[2] Accounting for Quantum Effects in Atomistic Spin Dynamics PRB 109, 174441 (2024).
[3] Intrinsic non-Markovian magnetisation dynamics, arXiv:2512.07378 (2025).
[4] Global Quantum Thermometry, PRL 127, 190402 (2021).
[5] Adaptive, symmetry-informed Bayesian metrology for precise quantum technology measurements, to appear in PRL (arxiv 2410.10615).

Bosonic Quantum Information from Superselection Rules

Pérola Milman (Université Paris Cité, CNRS, France)

Abstract. Bosonic systems, and in particular photonic platforms, are excellent candidates for implementing quantum information protocols that cannot be efficiently classically simulated. While non-Gaussianity is necessary for this so-called quantum advantage, it is not sufficient, leaving open the question of what truly constitutes a quantum resource in bosonic protocols. This talk addresses this question by treating the phase reference of bosonic states as an explicit quantum system rather than an implicit classical one, as usually done in quantum optics protocols. This perspective reveals that using an implicit classical phase reference both restricts the accessible state space and effectively fixes a computational basis. By incorporating the phase reference into the quantum formalism and respecting particle-number conservation and superselection rules, a basis-agnostic framework emerges in which the Gaussian/non-Gaussian dichotomy, for instance, appears as a limiting case. This approach clarifies, and permits unifying, the physical and computational resources underlying non-classicality and potential quantum advantage in bosonic systems of any kind.

Higher-order quantum algorithms for "advanced" quantum learning

Mio Murao (University of Tokyo, Japan)

Abstract. Efficiently learning properties of quantum objects is one of the key anticipated applications of quantum computers. We develop quantum algorithms for "advanced" quantum learning based on higher-order quantum computation, which transform a black-box quantum channel into either another quantum channel or a numerical quantity that characterizes its properties. In this framework, a quantum computer acquires “quantum data” about the channel through black-box queries and then outputs the target channel or evaluates the desired properties coherently, without reconstructing a full classical description of the black box. We present two such fully quantum algorithms for advanced learning of black-box quantum channels: one for universal unitary inversion, and another for learning the singular-value moments of an unknown quantum channel.

Continuous Variables multimode quantum networks: Theory and experiments
Valentina Parigi (Sorbonne Université - Laboratorie Kastler Brossel)

Abstract. I present continuous-variable (CV) photonic platforms based on frequency- and pulse-multiplexed squeezed states generated via nonlinear waveguides. These platforms enable scalable generation of continuous-variable quantum networks. I will present recent results on the theory and experimental implementation of the fundamental building blocks. In addition, protocols such as entanglement routing and reservoir computing will be discussed .

Ingredients for photonic quantum computing: entanglement, fusions, and integration
Stefanie Barz (IQST, University of Stuttgart, Germany)

Abstract. This talk explores key aspects of photonic quantum systems and their applications in quantum computing. It will cover three aspects: generation of resource states, fusion operations, and scalability via integration. I will begin by discussing quantum interference and its role in creating resource states for photonic quantum computing. Next, I will examine fusion operations, which form the fundamental building blocks for photonic quantum processors and networks. Finally, I will consider how photonic integration enables scalable architectures, highlighting both the opportunities and challenges in realising larger, more complex quantum systems

Hybrid Quantum Systems (HQS) for Quantum Battery Design and Simulation.
Alexandra Barbosa Gonzalez (Okinawa Institute of Science and Technology).

Abstract. Energy storage is becoming increasingly vital in modern society. Quantum batteries are an innovative approach that leverages quantum effects, such as entanglement and coherent cooperative interactions, to serve as temporary energy storage systems. Current theoretical protocols of quantum batteries have the potential to be implemented using hybrid quantum systems (HQS), which combine different quantum systems such as superconducting circuits, spin systems, and photonic modes to enhance the properties of the collective system. This project seeks to develop HQS-based quantum batteries, model their performance, and outline a road map for their practical implementation.

Wigner’s friend and the emergence of classicality.
Veronika Baumann (IQOQI Vienna), Tom Rivlin (Atominstitut, TU Wien) and Sophie Engineer (Institute of Photonics and Quantum Sciences).

Abstract. The Wigner's Friend thought experiment concerns quantum measurements by a 'superobserver' of an observer measuring a quantum system. Variations on the setup and its extended versions have lead to a series of no-go theorems that reveal new quantum effects and question the existence of absolute events. But most theoretical and experimental studies of Wigner’s Friend scenarios have restricted themselves to a 'friend' composed of a single qubit. We considered a specific, unitary model of the Friend’s measurement based on quantum Darwinism. We describe how to add environments to sim-

ple and extended WF scenarios in the quantum Darwinism framework, and present numerical results that study the emergence of classicality, in the form of the Friend's measurement result becoming more classical/objective. In both the simple and extended cases, we also find that the model and the environment obfuscate genuine WF effects and introduce strong restrictions on them. However, we also find a novel form of WF effect that exploits coherence between the Friend and the environment.

Using quantum sensing to provide physical layer security.
Charlie Hogg (University of Exeter), Marcelo Pereira de Almeida (University of Queensland), Janet Anders (University of Exeter and University of Potsdam) and Andrew White (University of Queensland).

Abstract. Physical-layer eavesdropping poses a huge challenge to the security of preexisting communication networks. Here, we investigate the use of two-photon interference, namely the Hong-Ou-Mandel effect, to provide physical-layer security in optical communication networks. Crucially, the HOM interference visibility is highly sensitive to the indistinguishability of the input photons. However, in the presence of environmental noise, and potentially also an Eavesdropper (Eve), this indistinguishability can be compromised. In this way, the HOM effect has the potential to act as a sensor for eavesdropping. Our work aims to theoretically model the sensor operation under the action of an eavesdropper (Eve) and other noise sources. We first consider an attack where Eve exploits optical losses to avoid detection. By analysing changes in the HOM interference visibility, we aim to show how continuous monitoring can be used to detect and prevent such physical-layer eavesdropping attacks.

Towards efficient industrial Continuous- Variables Quantum Key Distribution Systems.
Manon Huguenot (LIP6 - Sorbonne Université - CNRS), Yoann Piétri (LIP6 - Sorbonne Université - CNRS), Alexis Rosio (LIP6 - Sorbonne Université - CNRS), Philippe Grangier (Laboratoire Charles Fabry - IOGS - CNRS), Eleni Diamanti (LIP6 - Sorbonne Université - CNRS) and Baptiste Gouraud (Exail).

Abstract. Quantum Key Distribution (QKD) is a promising technology for cybersecurity and telecommunications, as it enables two distant parties to securely share a secret key. According to the laws of quantum physics, any eavesdropping attempt introduces detectable disturbances in the communication. Continuous-variable protocols (CV), which are compatible with standard telecommunication components -unlike Discrete-Variable (DV)-, have recently demonstrated high key rates. However, these demonstrations have mainly been limited to laboratory settings. Therefore, a key challenge is the development of industrial-grade CV-QKD systems capable of maintaining stable performance under real-world field conditions. Here we explore several configurations of an industrial CV-QKD system at both optical and processing levels and evaluate their integration within the European ecosystem. Our efforts focused on minimizing excess noise and maximizing the secret key rate. This led to a robust demonstrator, successfully tested on deployed optical fiber. Following its validation, we proceeded with detailed engineering and scalable production of a fully industrialized system. We are also involved in different European projects, to concretize the European Quantum Communication Infrastructure.

Motional entanglement in low-energy collisions near shape resonances.
Yimeng Wang (Freie Universität Berlin) and Christiane Koch (Freie Universität Berlin).

Abstract. Einstein, Podolsky, and Rosen discussed their paradox in terms of measuring the positions or momenta of two particles. These can become entangled upon scattering, but how much entanglement can be created in this process? Here we address this question with fully coherent calculations of bipartite scattering in three-dimensional space, quantifying entanglement by the inverse of the single particle purity. We show that the standard plane-wave description of scattering fails to capture the entanglement properties, due to the essential role of quantum uncertainty in the initial state. For a more realistic description of a scattering setup and narrow initial momentum dispersion, we find the entanglement to scale linearly with the scattering cross section, including strong enhancement close to shape resonances. We discuss how the generation of motional entanglement can be detected in experiment. Our results open the way to probing and eventually using entanglement in quantum collisions.

The Quantum Agreement Theorem.

María García Díaz (Universidad Politécnica de Madrid), Adam Brandenburger (New York University) and Giannicola Scarpa (Universidad Politécnica de Madrid).

Abstract. We formulate and prove an Agreement Theorem for quantum mechanics (QM), describing when two agents, represented by separate laboratories, can or cannot maintain differing probability estimates of a shared quantum property of interest. Building on the classical framework (Aumann, 1976), we define the modality of "common certainty" through a hierarchy of certainty operators acting on each agent's Hilbert space. In the commuting case -- when all measurements and event projectors commute -- common certainty leads to equality of the agents' conditional probabilities, recovering a QM analog of the classical theorem. By contrast, when non-commuting operators are allowed, the certainty recursion can stabilize with different probabilities. This yields common certainty of disagreement (CCD) as a distinctive QM phenomenon. Agreement is restored once measurement outcomes are recorded in a classical register. The classical Agreement Theorem can therefore be seen as emergent from the quantum world via recording. We establish an impossibility result stating that QM forbids a scenario where one agent is certain that a property of interest occurs, and is also certain that the other agent is certain that the property does not occur. In this sense, QM admits non-classical disagreement, but disagreement is still bounded in a disciplined way. We argue that our analysis offers a rigorous approach to the longstanding issue of how to understand intersubjectivity across agents in QM.

Quantum error correction with rotationally symmetric bosons codes.

Giulia Ferrini (Chalmers).

Abstract. I will focus on quantum error correction with boson codes. I will compare the performance of codes with rotational and translational symmetries under realistic conditions, and analyse their behaviour in the presence of relevant noise models such as photon losses and dephasing. Then, I will analyze their ability to correct errors stemming from non-Markovian error channels, such as the random telegraph noise. Finally, I will outline a new construction of multimode bosonic codes with rotational symmetry, demonstrating how they can achieve enhanced protection of quantum information.

Quantum reservoir computing in Jaynes-Cummings models: Nonlinear memory and time-series prediction.

Sreetama Das (Institute for Cross-Disciplinary Physics and Complex Systems (IFISC) UIB-CSIC), Gian Luca Giorgi (Institute for Cross-Disciplinary Physics and Complex Systems (IFISC) UIB-CSIC) and Roberta Zambrini (Institute for Cross-Disciplinary Physics and Complex Systems (IFISC) UIB-CSIC).

Abstract. We investigate quantum reservoir computing (QRC) using a hybrid qubit-boson system described by the Jaynes–Cummings (JC) Hamiltonian and its dispersive limit (DJC). These models provide high-dimensional Hilbert spaces and intrinsic nonlinear dynamics, making them powerful substrates for temporal information processing. We systematically benchmark both reservoirs through linear and nonlinear memory tasks, demonstrating that they exhibit an unusual superior nonlinear over linear memory capacity. We further test their predictive performance on the Mackey–Glass time series, a widely used benchmark for chaotic dynamics and show comparable forecasting ability. We also investigate how memory and prediction accuracy vary with reservoir parameters, and show the role of higher-order bosonic observables and time multiplexing in enhancing expressivity, even in minimal spin–boson configurations. Our results establish JC- and DJC-based reservoirs as versatile platforms for time-series processing and as elementary units that overcome the setting of equivalent qubit pairs and offer pathways towards tunable, high-performance quantum machine learning architectures.

Steady-State Multiparticle Entanglement via Dissipative Engineering in Waveguide QED.
Joan Alba Pares (Niels Bohr Institute) and Anders S. Sørensen (Niels Bohr Institute).

Abstract. We present a simple scheme for the dissipative creation of entangled states of multiple emitters coupled to a waveguide. Our approach exploits the collective interactions given by the creation of subradiant and superradiant excited states combined with the quantum Zeno effect. We show that starting from an arbitrary state, the system evolves into a W-type entangled steady state, with an infidelity inversely proportional to the cooperativity. The scheme is scalable to an arbitrary number of emitters. We analyze the effect of additional experimental errors and study in detail an implementation of the scheme with trapped 133Cs atoms.

Single-domain Bose condensate magnetometer achieves energy resolution per bandwidth below hbar.
Silvana Palacios Alvarez (IF-UNAM (Institute of Physics - National Autonomous University of Mexico)), Pau Gomez (ICFO (The Institute of Photonic Sciences)), Simon Coop (ICFO (The Institute of Photonic Sciences)), Roberto Zamora-Zamora (Quantum Technology Finland (QTF)) and Morgan Mitchell (ICFO (The Institute of Photonic Sciences)).

Abstract. We present a magnetic sensor with energy resolution per bandwidth ER <hbar. We show how a 87Rb single-domain spinor Bose–Einstein condensate, detected by nondestructive Faraday rotation probing, achieves single-shot low-frequency magnetic sensitivity of 72(8) fT, measuring a volume V = 1,091(30) μm3 for 3.5 s, and thus, ER = 0.075(16)hbar. We measure experimentally the condensate volume, spin coherence time, and readout noise and use phase space methods, backed by three-dimensional mean-field simulations, to compute the spin noise. Contributions to the spin noise include one-body and three-body losses and shearing of the projection noise distribution, due to competition of ferromagnetic contact interactions and quadratic Zeeman shifts. Nonetheless, the fully coherent nature of the single-domain, ultracold twobody interactions allows the system to escape the coherence vs. density trade-off that imposes an energy resolution limit on traditional spin precession sensors. We predict that other Bose-condensed alkalis, especially the antiferromagnetic 23Na, can further improve the energy resolution of this method.

Optimal control of a dissipative micromaser quantum battery in the ultrastrong coupling regime.
Maristella Crotti (Università degli Studi dell'Insubria; INFN, Sezione di Milano), Luca Razzoli (Università di Pavia; INFN, Sezione di Pavia), Luigi Giannelli (Università di Catania; INFN,

Sezione di Catania), Giuseppe A. Falci (Università di Catania; INFN, Sezione di Catania) and Giuliano Benenti (Università degli Studi dell'Insubria; INFN, Sezione di Milano).

Abstract. We investigate the open system dynamics of a micromaser quantum battery operating in the ultrastrong coupling (USC) regime under environmental dissipation. The battery consists of a singlemode electromagnetic cavity sequentially interacting, via the Rabi Hamiltonian, with a stream of qubits acting as chargers. Dissipative effects arise from the weak coupling of the qubit-cavity system to a thermal bath. Non-negligible in the USC regime, the counter-rotating terms substantially improve the charging speed, but also lead, in the absence of dissipation, to unbounded energy growth and highly mixed cavity states. Dissipation during each qubit-cavity interaction mitigates these detrimental effects, yielding steady-state of finite energy and ergotropy. Optimal control on qubit preparation and interaction times enhances battery's performance in: (i) Maximizing the stored ergotropy trhough an optimized charging protocol; (ii) Stabilizing the stored ergotropy against dissipative losses through an optimized measurement-based passive-feedback strategy. Overall, our numerical results demonstrate that the interplay of ultrastrong light-matter coupling, controlled dissipation, and optimized control strategies enables micromaser quantum batteries to achieve both enhanced charging performance and long-term stability under realistic conditions.

Enhancing wave–particle duality.

Arwa Bukhari (School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT.), Daniel Hodgson (School of Mathematical and Physical Sciences, University of Sheffield, Sheffield S3 7RH.), Sara Kanzi (Faculty of Engineering, Final International University, North Cyprus Via Mersin 10, Kyrenia 99370.), Robert Purdy (School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT.) and Almut Beige (School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT.).

Abstract. To enhance the consistency between the quantum descriptions of waves and particles, we quantise mechanical point particles in this paper in the same physically-motivated way as we previously quantised light in quantum electrodynamics (Bennett et al 2016 Eur. J. Phys. 37 014001). To identify the relevant Hilbert space, we notice that mechanical particles can occupy any position x while moving at any velocity v. Afterwards, we promote the classical states (x, v) to pairwise orthogonal quantum states |x,v> and demand that these evolve according to Newton's equations of motion. The resulting quantum theory is mass-independent, when Newton's equations of motion are mass-independent, as one would expect. The basic formulation of quantum mechanics emerges from quantum mechanics in configuration space as a semi-classical approximation when a fixed mass is imposed and several other adjustments are made.

Connecting time crystals to many-body protection.

Evi Kasnetsi (Universitat de València) and Carlos Navarrete-Benlloch (Universitat de València).

Abstract. 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 behavior.

Work Extraction from Anyonic Exclusion Statistics in a Quantum Otto Engine.

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Abstract. We present a four-stroke quantum heat engine whose working medium is the one-dimensional anyon Hubbard model. The central idea is to harness the low-temperature energy associated with anyonic exclusion statistics and convert it into finite, useful work via a hybrid anyon–Otto (HAO) cycle. In the noninteracting limit, we find that the work extracted at low temperature is maximized in the pseudo-fermionic regime, where anyons most closely emulate free fermions. When weak interactions are introduced, however, the optimum no longer occurs at either the bosonic or pseudo-fermionic endpoints; instead, the work output peaks at intermediate statistical angles. This reveals a nontrivial synergy between exchange statistics and interactions that enhances engine performance, with interacting anyons outperforming both bosons and pseudo-fermions in this regime. Finally, we outline a feasible experimental pathway to implement the HAO cycle using ultracold atoms confined in an optical lattice.

Hybrid quantum and classical reservoir computing architectures for quantum state processing.

Mateu Coll (University of Balearic Islands (UIB)), Gian Luca Giorgi (University of Balearic Islands (UIB)) and Roberta Zambrini (Consejo Superior de Investigaciones Científicas (CSIC)).

Abstract. Quantum reservoir computing (QRC) offers an alternative to classical reservoir computing (RC) for machine learning tasks by exploiting the degrees of freedom provided by Hilbert space. However, standard QRC designs cannot reliably perform nonlinear tasks with quantum inputs due to their inherently linear dependence on the input states. This work studies a hybrid architecture that combines a quantum reservoir—modeled as interacting qubits with a transverse field and local disorder—capable of processing quantum states, with an echo state network (ESN) that can faithfully execute nonlinear operations. We demonstrate that this hybrid approach outperforms its standalone components in both linear and nonlinear tasks, when limited to single-axis measure-

ments, i.e. partial information about the input, arising from the information spreading induced by the QRC preprocessing layer. Moreover, we implement the so-called online protocol —which accounts for back-action and finite trajectories—to study the impact of decoherence and noise on QRC and, consequently, on the hybrid system's performance. These results highlight the potential of hybrid quantum–classical architectures as a promising route for enhanced
quantum machine learning.

Photon emission without quantum jumps.

Almut Beige (University of Leeds), Thomas Hartwell (University of Leeds), Daniel Hodgson (University of Sheffield), Huda Alshemmari (University of Leeds) and Gin Jose (University of Leeds).

Abstract. When modelling photon emission, we often assume that the emitter experiences a random quantum jump. When a quantum jump occurs, the emitter transitions suddenly into a lower energy level, while spontaneously generating a single photon. However, this point of view is misleading when modelling quantum optical systems which rely on far-field interference effects for applications like distributed quantum computing and non-invasive photonic quantum sensing. In this paper, we highlight that the dynamics of an emitter in the free radiation field can be described by simply solving a Schroedinger equation based on a locally-acting Hamiltonian without invoking the notion of quantum jumps. Our approach is nevertheless consistent with quantum optical master equations.

A Predictive Discrete-Time Kalman Filter Model for Quantifying Measurement-Induced Two-Isotope Entanglement in Natural-Abundance Hot Mercury Vapor.

Hana Medhat (ICFO), Christopher Kiehl (ICFO) and Morgan Mitchell (ICFO).

Abstract. Thermal mercury vapor combines large atom number with long-lived nuclear-spin coherence, making it a strong candidate for quantum-enhanced magnetometry. We present a predictive model for a natural-abundance dual-isotope 199Hg/201Hg comagnetometer in which a single off-resonant probe near 254 nm continuously measures the collective spin state projection via Faraday rotation detected with balanced polarimetry. In a linear–Gaussian approximation, the coupled atom–light dynamics are formulated as a discrete-time Kalman filter for the joint mean vector and covariance matrix, including the collective spin-1/2 ensemble of 199Hg, a complete SU(4) multipole basis for the spin-3/2 ensemble of 201Hg capturing tensor (alignment) dynamics, and the relevant Stokes components of the probe. The dynamics are captured by a unified update rule combining coherent dispersive atom–light coupling, hot-vapor decoherence (spin relaxation and diffusion), and optical probe loss plus readout imperfections (absorption and finite detection efficiency). From the resulting covariances we evaluate metrological squeezing and a variance-based witness of 199Hg–201Hg entanglement, enabling quantitative predictions of both single-isotope squeezing and measurement-induced inter-isotope correlations in realistic hot-vapor conditions, with applications to precision field sensing, bias-noise rejection, and compact navigation-grade instrumentation.

QCL-based Self-Mixing platforms for Sensing and Communication.

Chenghong Zhang (CNR-INO (National Research Council - National Institute of Optics)), Tecla Gabbrielli (CNR-INO (National Research Council - National Institute of Optics)), Jacopo Pelini (CNR-INO (National Research Council - National Institute of Optics)), Simone Borri (CNR-INO (National Research Council - National Institute of Optics)) and Paolo De Natale (CNR-INO (National Research Council - National Institute of Optics)).

Abstract. Optomechanical platforms are promising for detecting light-induced mechanical motion with high sensitivity, broad spectral compatibility, and micro/nano-photonic integration. Self-mixing technique stands out as a compact approach in which the laser serves as both the source and the detector. We demonstrate two optomechanical platforms based on quantum cascade laser (QCL)-enabled self-mixing. First, we demonstrate a self-mixing optomechanical platform for transferring information between near- and mid-infrared lights through a membrane. In this configuration, we innovatively employ a mid-infrared QCL laser to read out the membrane displacement driven by amplitude-modulated near-infrared light. Based on this proof-of-concept study, we further exploit a self-mixing photoacoustic spectroscopy scheme, in which the photoacoustically induced oscillation of a micro-electro-mechanical system is detected through the dynamic optical feedback to the QCL. This configuration achieves a signal-to-noise ratio and minimum detection limit comparable to those of a bulk Michelson interferometer, while eliminating the need for external interferometric setups and photodetectors. Furthermore, the two demonstrated platforms can be extended to any desired wavelength owing to the intrinsic wavelength independence of both self-mixing and photoacoustic techniques. Overall, such self-mixing optomechanical platforms significantly expand the functional capabilities of QCL-based optomechanics, offering promising routes toward compact, chip-compatible, and wavelength-independent communication and spectroscopy technologies.

From Experimental Devices to Quantum Infrastructure: Ethical Questions of Optimization and Access.

Rebecca Mossop (DLR).

Abstract. Quantum computing is often discussed in terms of algorithms and future applications, yet its ethical challenges begin much earlier—at the level of hardware, infrastructure, and access. As quantum devices move from exploratory laboratory systems toward large-scale, fault-tolerant machines, ethical questions arise that concern not only what quantum computers can do, but how they reorganize scientific practice, responsibility, and power. In the current NISQ (Preskill, 2025) era, quantum hardware remains epistemically open: noisy, experimental, and accessible primarily through exploratory research contexts. Ethical questions in this phase are closely tied to uncertainty, risk, and experimental responsibility. At the same time, optimization already functions as a normative force, shaping which experiments, benchmarks, and research practices are considered feasible or valuable—albeit in ways that remain provisional and open to revision. By contrast, the anticipated transition to fault-tolerant and scalable quantum computing (often referred to as FASQ (Preskill 2025)) marks a qualitative shift. Quantum hardware becomes reliable, reproducible, and infrastructure-like—capable of stabilizing specific computational outcomes and, with them, persistent scientific priorities. In this context, optimization no longer merely improves experimental performance; it becomes structurally embedded in hardware design and operation, shaping which forms of knowledge production are feasible, visible, and institutionally supported. As a concrete example, quantum computing time can be understood as a scarce and powerful epistemic good. Access to hardware time increasingly determines which research questions can be pursued across quantum optics, many-body physics, and quantum information science. Who decides how this resource is allocated? On what grounds are priorities set? And how can fairness, inclusion, and epistemic responsibility be preserved as quantum hardware becomes centralized and costly? By framing quantum hardware as an ethical object in its own right, this contribution proposes a conceptual framework for anticipating governance challenges before technological paths become entrenched. The aim is not to constrain scientific progress, but to ensure that emerging quantum infrastructures support responsible, inclusive, and virtuous scientific practice.

Resource-Efficient Quantum Extreme Learning Machine with Gaussian Boson Sampling.

Daniel Montesinos Capacete (Institute for Cross-Disciplinary Physics and Complex Systems), Roberta Zambrini (Institute for Cross-Disciplinary Physics and Complex Systems) and Gian Luca Giorgi (Institute for Cross-Disciplinary Physics and Complex Systems).

Abstract. The rising cost of training large machine-learning models motivates the development of hardware-efficient learning approaches. Quantum reservoir-inspired models are particularly attractive on noisy intermediate-scale quantum platforms, since the quantum dynamics remain untrained and only a simple classical readout is learned. Here, we propose a multiclass quantum extreme learning machine implemented with a Gaussian boson sampling (GBS) device. Classical inputs are jointly encoded in the squeezing parameters and the interferometer unitary, enabling sampling-based, highly nonlinear feature maps while leveraging the fact that simulating large-scale GBS output statistics is widely believed to be classically intractable. Through numerical simulations, we achieve high classification accuracy on the MNIST task with only 12 spatial modes, substantially fewer than in recent experimental GBS demonstrations of the same task. We systematically compare multiple families of quantum features accessible in the same setup and find that photon-number sampling probabilities provide the best performance, consistent with their higher effective feature dimensionality. Finally, we benchmark against classical nonlinear baselines and analyse robustness under realistic noisy scenarios, showing competitive performance with fewer trainable parameters and indicating practical promise for near-term photonic implementations.

Photonic Architecture for Quantum Machine learning.

Kae Nemoto (Okinawa Institute of Science and Technology), Akitada Sakurai (Okinawa Institute of Science and Technology), Aoi Hayashi (Graduate University for Advanced Studies, SOKENDAI) and William Munro (Okinawa Institute of Science and Technology).

Abstract. Quantum extreme reservoir computation has shown a way to use a small quantum system to perform machine learning tasks. In this talk, we extend this concept to the regime of photonic. By using an array of beam splitters, we design photonic architecture to perform quantum machine learning for classification problems. This quantum-classical integrated model achieves remarkably high performance with a few photons.

Fast neutral-atom transport and transfer between optical tweezers.

Cristina Cicali (Forschungszentrum Jülich and Institute for Theoretical Physics, University of Cologne), Martino Calzavara (Forschungszentrum Jülich and Institute for Theoretical Physics, University of Cologne), Eloisa Cuestas (Forschungszentrum Jülich and OIST, Onna, Okinawa (Japan)), Tommaso Calarco (Forschungszentrum Jülich and Institute for Theoretical Physics, University of Cologne), Robert Zeier (Forschungszentrum Jülich) and Felix Motzoi (Forschungszentrum Jülich and Institute for Theoretical Physics, University of Cologne).

Abstract. We study the optimization of the transport and transfer of neutral atoms between optical tweezers, both critical steps in the implementation of quantum computers and simulators. We analyze four experimentally relevant pulse shapes (piecewise linear, piecewise quadratic, minimum jerk, and a combination of linear and minimum jerk), and we also develop a protocol using shortcuts-to-adiabaticity (STA) methods to crucially incorporate the time-dependent effects of static traps. By computing a measure of the final transport error and two measures of the heating during transport, we show that our proposed STA protocol compre-hensively outperforms all the experimentally inspired pulses. After further optimizing the pulse shapes, we find a lower bound on the protocol duration,

compatible with the time at which the vibrational excitations exceed half of the states hosted by the moving tweezer. This lower bound is at least eight times faster than the one reported in recent experiments, which highlights the importance of including and optimizing the transfer from and to static traps, which may be the largest bottleneck to speed. Finally, our STA results demonstrate that a modulation in the depth of the moving tweezer designed to time-dependently counteract the effect of the static traps is key to reducing errors and reducing the pulse duration. To motivate the implementation of our STA pulses in future experiments, we provide a simple analytical approximation for the moving-tweezer position and depth controls.

Quantum Monte Carlo study of systems interacting via long-range interactions mediated by a cavity.

Marta Domínguez-Navarro (Insitut de Ciències del Cosmos Universitat de Barcelona (ICCUB)), Abel Rojo-Francàs (Okinawa Institute of Science and Technology (OIST)), Bruno Juliá-Díaz (Universitat de Barcelona) and Grigori E. Astrakharchik (Universitat Politècnica de Catalunya).

Abstract. We study one-dimensional quantum gases in continuous space with cavity-mediated infinite-range interactions using variational and diffusion Monte Carlo methods. Starting from the exact two-body solution, we construct a non-translationally invariant Jastrow wavefunction that accurately captures the spatial structure induced by the cavity field and provides an efficient many-body ansatz for both bosonic and fermionic systems. We analize properties of three characteristic quantum systems, subject to long-range interactions: (i) ideal Bose gas (ii) interacting Bose gas (iii) ideal Fermi gas. In the absence of short-range interactions, we identify a crossover from a stable, weakly modulated phase realized for repulsive interactions to a delocalized bound state for attractive interactions, marked by clustering, loss of superfluidity, and the absence of a thermodynamic limit. Introducing short-range repulsion, either through contact interactions or fermionic statistics, leads to the formation of a mesoscopic gas-like regime that disappears in the thermodynamic limit. A qualitative phase diagram is proposed to illustrate the combined effects of short- and long-range interactions, highlighting the emergence of distinct regimes with characteristic structural properties.

Coherent control of circular dichroism in ion yield of chiral molecules.

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Abstract. The use of shaped femtosecond laser pulses is a proven strategy for directing reaction and excitation pathways in molecular systems [1,2]. In this work, we demonstrate coherent control of Circular Dichroism in Ion Yield (CDIY) in 3-methylcyclopentanone using tailored femtosecond UV pulses. By manipulating pulse duration, linear chirp, and central wavelength, we achieve significant modulation of the CDIY signal, revealing sensitivity of the chiral response to the temporal and spectral structure of the excitation field. Additionally, conformer dynamics of the molecule in the excited state may contribute to enhanced CDIY. Building on these findings, we are now extending our control to substituted fenchone using similar pulse parameters but at visible wavelengths. We aim to extend our control over CDIY by exploiting more flexible and customized pulse shapes through advanced pulse shaping techniques.

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Measuring Bohmian Trajectories in a Double Slit Experiment.

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Abstract. Bohmian mechanics is an alternative interpretation of quantum mechanics that solves the measurement problem by providing a realist account of quantum phenomena.

Attributing definite positions to particles at all times allows, in strong contradiction to standard quantum mechanics, the introduction of particle trajectories, explaining measurement outcomes. Yet, this necessarily comes with non-local effects, which can lead to instantaneous changes of the trajectory of a particle upon changes at a remote location of the setup. Bohmian trajectories can be inferred and, indeed, have been shown to correspond to the predicted ones in stationary setups [1,2]. In our experiment, we want to introduce time-dependent which-way and delayed-choice quantum erasure in order to explore the non-locality of the theory. We record the Bohmian trajectories of a photon, entangled with a second photon, in a double slit interferometer, such that we are able to analyze the evolution of the interfering photon depending on the observation of the second photon. By varying the point in time of the measurement of the second photon, we can switch between interference and which-path analysis in a delayed-choice manner. This enables us to directly investigate the need and consequences of the non-local mechanism in Bohmian mechanics.

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Optimizing energy conversion with nonthermal resources in steady-state quantum devices.

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Abstract. In quantum transport, particle currents are investigated through quantum devices coupled to multiple contacts, which are defined by their electrochemical potentials and temperatures. However, when reaching the nanoscale, particles might no longer equilibrate with their thermal surroundings. Consequently, in the investigation of energy conversion processes, nonthermal distributions become highly relevant descriptors of the particles' environment. I will present how a nonthermal resource can be exploited to generate power or cool a contact and how to maximize the efficiency or precision for these processes. Utilizing coherent electron scattering, the optimization is made by adjusting the transmission probabilities of electrons at different energies. Importantly, we also address the issue of how to define an efficiency as the energy current cannot be neatly divided into heat and work, due to the presence of a nonthermal resource. Based on this, we show that for a fixed output current the optimal transmission function is a series of band-passes in the energy spectrum, depending on the shape of the nonthermal distribution. When applying this result on example systems with nonthermal resources we find that all performance quantifiers improve compared to thermal counterparts. These findings highlight the importance of designing nanoelectronic devices according to the electron distributions their contacts.

Trade-offs between weak continuous and strong quantum measurement.

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Abstract. The primary objective of this work is to quantify the fundamental energetic costs associated with quantum measurements [1]. To this end, we develop and analyze a minimal model that captures the essential aspects of the measurement process. Our framework accounts for scenarios in which partial or complete information is obtained from a quantum system during the measurement protocol, encompassing a spectrum of measurements ranging from weak to strong, and varying in detection efficiency from ideal (fully efficient) to highly lossy (inefficient). Our model consists of a quantum system of interest, S, and an auxiliary system, A, which serves as an ancilla to facilitate information extraction. The measurement process unfolds in several key stages: the ancilla is first initialized, then coupled to the system, allowing information transfer through their interaction modelled via a unitary, enabling measurements ranging from weak to strong. We consider the irreversibility of the quantum measurement process by assuming that the ancilla undergoes pure dephasing induced by inaccessible degrees of freedom of the measuring apparatus. The ancilla is then read out, transferring the measurement result to a classical memory, which is reset, after utilizing the extracted information, alongside the ancilla to ensure the process remains repeatable. Unlike previous studies on the energetics of measurements, our model explicitly incorporates weak measurements. To characterize the quality of this protocol, we introduce three figures of merit that we found essential in this case, the strength characterizing the amount of information that can be extracted from the system, the detection efficiency characterizing the amount of information that has left the system and could be found in the accessible degrees of freedom of the ancilla and the normalized classical mutual information, which quantifies how much information about a specific observable is available in the accessible degrees of freedom of the ancilla. We found that the three of them were essential to characterized the quality of the measurement. We determine a fundamental lower bound on the work cost of this protocol and contrast it with an alternative approach in which dissipation, rather than dephasing, is used to convert quantum information into classical form [2]. Our analysis reveals that the energetic cost in the dephasing case is always greater than or equal to that in the dissipation case. We have also analyzed the role of coarse-graining of the ancilla outputs in the quality and cost of this setup and we have found that the lower work bound is not modified by coarse-graining as long as the coarse-graining spaces remain orthogonal between themselves. Furthermore, we explore different routes to achieving strong and efficient measurements. One approach is to implement a single strong measurement via an intense/long interaction with the ancilla, while another relies on a long sequence of consecutive weak measurements.

By comparing their energetic costs, we find that the work bound for multiple successive weak measurements significantly exceeds that of a single strong measurement. Our findings shed light on the interplay between energy expenditure and measurement performance, offering insights into the thermodynamic constraints governing quantum measurements.

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Improving Single-Excitation Fidelity in Rydberg Superatoms for Efficient Single Photon Emission.

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Abstract. Deterministic single photon emission from a Rydberg ensemble coupled to an optical cavity requires high-fidelity preparation of collective single excitations. Imperfect Rydberg blockade can lead to unwanted double excitations, which degrade photon indistinguishability. We adapt the Derivative Removal by Adiabatic Gate (DRAG) technique, originally developed for superconducting qubits, to shape optical pulses that suppress double excitations in this atomic platform. By combining analytical modeling with numerical optimization, DRAG provides an improvement over conventional sine-squared pulses. Further optimization of pulse duration and atomic ensemble size identifies a parameter regime, distinct from that used in [Nature Photonics 17, 688 (2023)], that enhances the single-excitation probability from the previous theoretical benchmark of 77% to 91.94%, approaching the fundamental limits set by decoherence in the system. Benchmarking against GRAPE (Gradient Ascent Pulse Engineering) confirms that DRAG operates close to the optimal control limit, while maintaining a smooth, experimentally practical pulse shape. These results demonstrate the effectiveness and cross platform adaptability of DRAG for a high-fidelity single photon source.

Coupling a single spin to the motion of a carbon nanotube.

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Abstract. The ability to couple a solitary spin to high-frequency motion is a crucial advancement for a range of applications, including quantum sensing, intermediate and long-distance spin-spin coupling, and quantum information processing. Although proposed theoretically over a decade ago, experimental demonstrations have remained elusive. Here we report the observation of spin-mechanical coupling in a carbon nanotube device. We demonstrate this coupling in two configurations: off-resonant, with spin and mechanics excited by separate tones, and resonant, driven by a single tone. The coupling manifests as a shift and broadening of the electric dipole spin resonance (EDSR), respectively. Our theoretical model, which accounts for the tensor character of the coupling and mechanical non-linearity, reproduces the data with very good agreement. Our results demonstrate a previously unobserved spin-mechanical coupling, offering versatile tools for exploring macroscopic quantum phenomena, quantum thermodynamics, and quantum simulation.

Synthetic Dimensions Realised in Ultracold Molecules.

Francesca Blondell (Durham University), Adarsh Raghuram (Durham University), Jonathan Mortlock (Durham University), Benjamin Maddox (Durham University), Philip Gregory (Durham University) and Simon Cornish (Durham University).

Abstract. Ultracold molecules offer an exciting platform for quantum simulation owing to their dipole moments, long-lived excited states and rich internal structures [1]. Com-

bining this with quantum gas microscopy techniques opens up a wide array of possibilities for quantum simulation. We have realised the first synthetic dimension in ultracold molecules which we have benchmarked through probing the Su-Schrieffer-Heeger (SSH) model in 4-,6-, and 8-site synthetic lattices. We realise the SSH model through coupling different rotational levels of the molecule using stroboscopic microwave pulses. Recent advances using magic wavelength [2,3] trapping allow us to probe the synthetic dimension over tens of tunnelling times. We use this platform to probe the edge and bulk states of the system, accurately measure edge state energy splittings, and show topological protection of the edge states. The winding number of the system is extracted to probe the topological phase transition. The rich internal structure offered by molecules offer possibilities of investigating more complex synthetic dimensions in, such as investigating the effect of dipole-dipole interactions on synthetic lattice dynamics [4,5].

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Quasiprobabilities from incomplete and overcomplete measurements.

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Abstract. We discuss the (re-)construction of quasiprobability representations from generic measurements, including noisy ones. Based on the measurement under study, quasiprobabilities and the associated concept of nonclassicality are introduced. A practical concern that we address is the treatment of informationally incomplete and overcomplete measurement scenarios, which can significantly alter the assessment of which states are deemed classical. Notions, such as Kirkwood–Dirac quasiprobabilities and s-parametrized quasiprobabilities in quantum optics, are generalized by our approach. Single-qubit systems are used to exemplify and to compare different measurement schemes, together with the resulting quasiprobabilities and set of nonclassical states.

Analysing adiabatic computation through the lens of closest approximate symmetries.

Ana Palacios (Qilimanjaro Quantum Tech S. L. / University of Barcelona), Artur Garcia Saez (Barcelona Supercomputing Center / Qilimanjaro Quantum Tech S.L.), Arnau Riera (Qilimanjaro Quantum Tech S. L.) and Marta P. Estarellas (Qilimanjaro Quantum Tech S.L.).

Abstract. In Adiabatic Quantum Computation (AQC), we compute by (adiabatically) interpolating between an initial Hamiltonian A, in whose ground state we initialise, and a final Hamiltonian B, whose ground state we want to prepare. The hardness of this process is then, loosely speaking, determined by the structural differences between A and B. In the adiabatic theorem, these “structural differences” materialise through transition matrix elements between instantaneous eigenstates, carrying information about shared symmetries, and instantaneous energy gaps, which carry the aftermath of the complex interplay between the eigenvalues and eigenspaces of A and B. This work puts forth a new frame-

work to unravel this interplay based on the idea of Closest Approximate Symmetries (CAS) by recursively projecting onto reduced representations of A and B, such that the error between this (largely simplified) representation of the computation and the original one is minimised. This method provides an analytical estimate of the energy landscape that can be used to make statements about the hardness of the process, both qualitative (e.g., the gap will remain large), as well as quantitative (e.g., estimates on minimum gap locations, bounds on the maximum size of the minimum gap along the computation). The CAS framework has also revealed a new heuristic for classical optimisation problems when applied to the standard quantum annealing setting, and we believe it could have further applications in the design of analog algorithms or the study of phase diagrams.

Coherent Control for Quantum Metrology.

Phila Rembold (Atominstitut, TU Wien), Mohammad Mehboudi (Atominstitut, TU Wien) and Nicolai Friis (Atominstitut, TU Wien).

Abstract. We analyse the potential of coherent control, the “if–then” structure of quantum mechanics, for quantum metrology. Standard metrological frameworks based on unitary and Markovian dynamics are widely applicable, but also restrict the available class of operations. In practice, experimental quantum processes often go beyond these assumptions. Coherent control is a higher-order process in which the channel applied to a target system is conditioned on the state of a control system. Here, “higher order” means that the process acts on operations rather than directly on states. It can be seen as a CNOT gate, where the NOT operation is replaced with an arbitrary black-box channel, which we exploit for sensing. We show that coherent control provides an additional operational degree of freedom that can enhance sensitivity beyond the standard prepare–unitary–measure paradigm, and we identify an example where it could provide an advantage.

Quantum Toolbox for Neurobiology Sensory Systems.

Marilu Chiofalo (University of Pisa).

Abstract. The quantum-like paradigm refers to describing non-linear, dynamical, complex phenomena using quantum mechanics, where complex correlations arise from entanglement, while taking advantage of the linearity of quantum information processing. The advantage of this approach has already been demonstrated for various non-linear dynamics phenomena from fluid dynamics to neuroscience. In a quantum- and neuroscience truly interdisciplinary research, we have found one such example of an open quantum spin network mapping a neural system. Surprisingly, it can simulate the human sense of number as a native global dynamical property, where current bio-inspired models like Artificial Neural Networks perform rather poorly. After illustrating the outcomes of this research, I will discuss its potential implications on two questions: (1) whether we can simulate other important complex phenomena observed in neuroscience, whose mechanisms are yet unknown; (2) which properties of the quantum network would lead to the most effective and efficient simulation of complex systems nonlinear dynamics. I will present preliminary results on the latter question, where we use the topology of complex quantum networks as a resource, tuning the range of power-law inter-nodes interactions and their regular vs. random architecture.

Applying Shuttling Optimal Control to Cryogenic Electronics.

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Abstract. The SpinBus architecture [M. Künne, et al., Nat. Commun. 15, 4977 (2024).] is a promising application of spin shuttling necessary for scaling up spin qubit systems using a sparse grid of qubits. Using cryogenic electronics enables the inclusion of control electronics close to the qubit, mitigating the wiring bottleneck, reducing power cost and signal distortion. This benefit comes at the cost of requiring intricate co-simulation and pre-silicon verification tools and methodologies [P. Dietz Romero, et al., Proc. SMACD 2025, 1–4 (2025)].
We adopt optimal control theory in cryogenic electronics within a cross-domain collaboration between quantum physicists and integrated circuit designers. In the spin-bus architecture, the electron is shuttled across a Si/SiGe heterostructure. The effect of the substrate at the silicon-germanium interface influences The electron's valley state which becomes highly unpredictable and in turn the information on the spin state of the electron is lost via the spin-valley entanglement. Changes in the valley state of the electron lead to changes in the g-factor, causing a valley-dependent phase on the spin evolution. These effects deteriorate the purity of the spin and lead to dephasing. In this work we apply optimal control using a valley-aware shuttling strategy , as described in [A. David, et al., Preprint arXiv:2409.07600v1 (2024).], onto an existing integrated circuit design of an ultra-low-power cryogenic shuttling signal generator. Due to limitations in measuring device-specific valley maps, we use simulated valley map datasets generated using a diffusion model [Paquelet Wuetz, B., Losert, M. P., et al., Nat Commun 13, 7730 (2022)]. An optimizer tunes the pulse shapes in the digital twin depending on the valley map experienced by the electron. We advocate for this approach by demonstrating its feasibility through modeling and artificial datasets. Tuning involves adjusting the parameters of the electronic circuit offered by the cryogenic shuttling chip to achieve high spin purity and shuttling fidelity by adjusting the pulses of the shuttling signal generator. We plan to run the modeled shuttling control on our real cryogenic chip integrated with a qubit to verify the effectiveness of the digital twin.

Integrating Quantum Algorithms for Molecular Dynamics.

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Abstract. The investigation of ultrafast electron-nuclear dynamics in molecules requires solid theoretical methods for interpretation purposes. The large number of electronic and nuclear degrees of freedom often represents a limitation in accurately predicting the behavior and dynamics of chemical systems on classical computers. To address these challenges and improve computational capabilities, it could be beneficial for quantum and classical computers to collaborate, taking advantage of their strengths to enhance the efficiency of theoretical-chemistry simulations [1]. With this aim in mind, there have been already studies on molecular dynamics using quantum computing [2-5]. Building on this past research, our work seeks to perform an excited-state molecular dynamics simulation on the methyl imine molecule combining an existing non-adiabatic molecular dynamics technique, Surface Hopping, with quantum algorithms. We replace conventional electronic energy and overlap calculations with the Variational Quantum Deflation (VQD) algorithm and the Hadamard Test method, respectively, using the spin-restricted ansatz [6]. Finally, we evaluate the accuracy and feasibility of different gradient calculations approaches integrated with quantum algorithms [7]. And we show how adjustments to cer-

tain variables within the methodology can facilitate integration. Motivated by previous work challenges, where the choice of initial states directly affects the accuracy and cost of energy calculations, we also introduce a three-step approach that optimizes multiple short-depth quantum circuits [8] and solves a generalized eigenvalue problem, reducing problem dimensionality while remaining compatible with hybrid quantum-classical schemes. Applied to molecular systems, including those with triple bonds and degeneracies, our method demonstrates its effectiveness for excited-state calculation. As a third study and to push things further, we are implementing small-scale, first-quantized grid simulations of ultrafast electron dynamics in atoms and molecules. Following recent proposals for real-space quantum dynamics algorithms [9] and using our prior experience in large scale simulations in classical computing [10], we aim to build a new set of scalable algorithms incorporating all degrees of freedom at equal footing.

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Approximating the Jones Polynomial using Simulated Fibonacci Anyons.

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Abstract. The question of determining whether or not two knots are equivalent is considered a hard problem. Knot invariants are defined to characterize knots. One such knot invariant is the Jones polynomial. Calculating the Jones polynomial of a knot requires time exponential in the number of crossings and is classically categorized as #P-hard. However, we can approximate the Jones polynomial using quantum algorithms, showcasing their advantage compared to classical algorithms. It has been shown that certain topological quantum computers can be used to efficiently approximate the Jones Polynomial by representing knots as trace closures of anyon worldlines in space-time and measuring the amplitudes of specific fusion channels. In this project, we use qubits to simulate the Doubled Fibonacci topological order within the Levin-Wen string-net model using generic non-topological qubits. We aim to design circuits to simulate the initialization and braiding of anyons that trace out simple knots and carry out projective measurements to determine the phase and amplitude of the corresponding braiding matrices. We verify our results by comparing them to analytical calculations of the Jones polynomial derived from evaluating the Kauffman bracket of each knot. We have designed circuits for the implementation and measurement of the Jones polynomial corresponding to a simple twist

knot using 9 and 14 qubits, and verified our results with the Kauffman bracket. Currently, we are working on designing circuits that simulate the trefoil knot and Hopf link using 14 qubits, and further studies could explore more complicated knots.

Generation of noise-induced Fano coherence in a V-type atomic system interacting with incoherent radiation.

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Abstract. In multi-level quantum systems, coherent superposition states can unexpectedly arise from interactions with the continuum of modes associated with incoherent processes, such as spontaneous emission and incoherent pumping [1, 2]. The formation of quantum coherence between internal states generated by "noisy" conditions has particular significance for systems in contact with thermal reservoirs, such as quantum heat engines, or with thermal radiation, as customary in photo-conversion devices. As suggested in [3, 4], their performance could see improvements. This type of coherence, known as noise-induced Fano coherence, represents a novel observation that has not yet been documented. We propose a V-type three-level quantum system realized in the hyperfine structure of hot 87Rb atoms in a vapor cell, and a proof-of-principle experiment has been designed and conducted. The experimental setup employs angle-resolved fluorescence measurements to detect Fano coherence via spatial anisotropy of the emitted fluorescence around the vapor cell when the system is driven by incoherent radiation [5]. Preliminary results are promising and are consistent with theoretical predictions. Additionally, this work explores the quantum thermodynamics of noise-induced Fano coherence to certify the presence of genuinely quantum traits underlying its generation [6]. This includes analyzing the conditions under which the Kirkwood-Dirac quasiprobability distribution of the stochastic energy changes exhibits negativity, indicating non-classical traits. The study also demonstrates the existence of non-equilibrium regimes where, the generation of coherence leads to a significant excess of energy compared to the initial state, provided that the system begins in a superposition of energy eigenstates. Understanding how Fano coherence arises in multi-level systems through incoherent optical processes is crucial for its potential applications in enhancing the efficiency of quantum heat engines, photosynthetic light-harvesting complexes, and photovoltaics. The associated excess energy could be exploited as extractable work by external loads or storage systems, thereby offering significant technological advancements and potentially paving the way for the development of novel high-efficiency devices.

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Thermal rectification in a qubit-resonator system.

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Abstract. A qubit-oscillator junction connecting as aseries two bosonic heat baths at different temperatures can display heat valve and diode effects. In particular, the rectification can change in magnitude and even in sign, implying an inversion of the preferential direction for the heat current with respect to the temperature bias. We perform a systematic study of these effects in a circuit QED model of qubit-oscillator system and find that the features of current and rectification crucially depend on the qubit-oscillator coupling. While at small coupling, transport occurs via a resonant mechanism between the subsystems, in the ultrastrong coupling regime the junction is a unique, highly hybridized system and the current becomes largely insensitive to the detuning. Correspondingly, the rectification undergoes a change of sign. In the nonlinear transport regime, the coupling strength determines whether the current scales sub- or super-linearly with the temperature bias and whether the rectification, which increases in magnitude with the bias, is positive or negative. We also find that steady-state coherence largely suppresses the current and enhances rectification. An insight on these behaviors with respect to changes in the system parameters is provided by analytical approximate formulas.

Thermodynamics of Driven Open Quantum Systems: The Role of Coherences and Partial Secularization.

Luisa Toledo Tude (IFISC (Institute for Cross-Disciplinary Physics and Complex Systems)), Roberta Zambrini (IFISC (Institute for Cross-Disciplinary Physics and Complex Systems)) and Gonzalo Manzano (IFISC (Institute for Cross-Disciplinary Physics and Complex Systems)).

Abstract. Periodically driven open quantum systems are central to quantum thermodynamics and control, yet their theoretical description requires careful handling of approximations. These systems are typically described using Floquet-Born-Markov master equations that are derived with the use of a strong secular approximation whose thermo-dynamic implications are often overlooked. In this context, we show that the full secular approximation leads to incorrect predictions for steady-state energy currents in driven systems. We demonstrate that a coarse-grained formulation of the Floquet–Redfield master equation can regularize these inconsistencies while yielding thermodynamically consistent energy currents. The coarse-graining time has a clear physical interpretation, defining the temporal resolution at which a Markovian master equation can describe the evolution of a periodically driven system. We investigate the consistency and validity of this approximation in paradigmatic examples: a driven two-level system and a three-level maser coupled to both a hot and a cold reservoir.

Charging Efficiency and Correlation Effects in Double Quantum Dot Quantum Batteries.

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Abstract. Abstract: Quantum batteries (QBs) have been proposed as devices that take advantage of quantum resources, such as coherence and entanglement, to improve charge performance. This work presents a theoretical study of a quantum battery model based on two coupled double quantum dots (TDQDs) implemented on the AlGaAs/GaAs platform. Ergotropy and power are used as key indicators to analyze the influence of system parameters on energy performance. Results show that increasing the energy offset enhances ergotropy and power while reducing quantum coherence, whereas stronger tunneling couplings lead to a non-monotonic variation in ergotropy correlated with entan-

glement. These findings confirm the potential of quantum dots for efficient energy storage and emphasize that coherence alone is insufficient, with other quantum correlations being essential for optimal performance.

Hybrid Reward-Driven Reinforcement Learning for Efficient Quantum Circuit Synthesis.
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Abstract. A reinforcement learning (RL) framework is introduced for the efficient synthesis of quantum circuits that generate specified target quantum states from a fixed initial state, addressing a central challenge in both the Noisy Intermediate-Scale Quantum (NISQ) era and future fault-tolerant quantum computing. The approach utilizes tabular Q-learning, based on action sequences, within a discretized quantum state space, to effectively manage the exponential growth of the space this http URL framework introduces a hybrid reward mechanism, combining a static, domain-informed reward that guides the agent toward the target state with customizable dynamic penalties that discourage inefficient circuit structures such as gate congestion and redundant state revisits. This is a circuit-aware reward, in contrast to the current trend of works on this topic, which are primarily fidelity-based. By leveraging sparse matrix representations and state-space discretization, the method enables practical navigation of high-dimensional environments while minimizing computational overhead. Benchmarking on graph-state preparation tasks for up to seven qubits, we demonstrate that the algorithm consistently discovers minimal-depth circuits with optimized gate counts. Moreover, extending the framework to a universal gate set still yields low depth circuits, highlighting the algorithm robustness and adaptability. The results confirm that this RL-driven approach, with our completely circuit-aware method, efficiently explores the complex quantum state space and synthesizes near-optimal quantum circuits, providing a resource-efficient foundation for quantum circuit optimization.

Emergent topology by Landau level mixing in quantum Hall-superconductor nanostructures.
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Abstract. A two-dimensional electron gas (2DEG) in the presence of a strong magnetic field exhibits the quantum Hall (QH) effect, which supports chiral 1D conducting states at the edges. Proximity to a superconductor (SC) leads to the formation of chiral Andreev edge states (CAES)[1-3]: hybridized electron-hole states with promising potential applications in quantum metrology and topologically protected quantum computing. Although the strong magnetic fields required for the QH effect are detrimental to superconductivity, recent experiments have achieved QH-SC hybrid junctions based on InAs 2DEGs [4], graphene [5], and magnetic topological insulators [6]. Although these experiments involve conventional SCs, where Cooper pairs are formed by electrons with opposite spins, experimental evidence for emerging CAESs has been found even in the lowest QH edge states, where spins are polarized by ultra-strong Zeeman coupling. In this study [7], we theoretically investigate the formation of CAESs in hybrid junctions consisting of a superconducting stripe on top of a 2DEG. Hybridization of CAESs from both sides of the SC finger yields a complex phase diagram showing different topological phases, which de-

pend on system parameters such as the chemical potential and the width of the SC stripe. Among these phases, we found a realization of the long-sought p-wave superconducting state at even filling factors, enabling its detection at lower fields. We demonstrate that distinct gapped phases exhibit specific signatures in nonlocal electron transport and that topological phases are resilient to disorder and edge imperfections.
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Probing time-reversal symmetry breaking in twisted bilayer cuprates.

Silvia Neri (Max Planck Institute for Solid State Research), Dirk Manske (Max Planck Institute for Solid State Research) and Marcel Franz (University of British Columbia).

Abstract. Superconducting states in which nematicity and time-reversal symmetry breaking coexist or compete can host unconventional complex order parameters and novel collective excitations. In this work, we investigate such phenomena in twisted bilayer cuprates, an engineered platform whose phase diagram can be tuned via the twist angle. We focus on superconducting phases characterized by a complex admixture of pairing channels of the form $\Delta_1 + \Delta_2 \exp(i \phi)$, with $\phi \neq 0, \pi$, stabilized by the interplay between nematic and time-reversal symmetry–breaking tendencies. To characterize the signatures of this competition, we analyze the collective modes of the system. Starting from a microscopic model, we integrate out the electronic degrees of freedom of one layer to obtain an effective Hamiltonian for the remaining layer. We compute the quasiparticle density of states and analyze how collective modes associated with the competing orders couple to Bogoliubov quasiparticles. We discuss the resulting signatures in the local density of states and assess their detectability in scanning tunneling microscopy experiments. Our results establish twisted bilayer cuprates as a promising platform to probe collective excitations in superconductors with intertwined nematic and time-reversal symmetry–breaking orders.

Fast Open-Path Detection of Organic Gases in Air via Quantum Fourier-Transform Mid-Infrared Spectroscopy.

Fériel Armbruster (FEMTO-ST Institute, Besançon), Adimulya Kartiyasa (Université de Genève, Genève), Shayantani Ghosh (Université de Genève, Genève), Geoffrey Gaulier (Université de Genève, Genève), Luca La Volpe (Université de Genève, Genève), Simon Neves (FEMTO-ST Institute, Besançon), Fabrice Devaux (FEMTO-ST Institute, Besançon) and Jean-Pierre Wolf (Université de Genève, Genève).

Abstract. In recent years, the detection of organic gases, also known as volatile organic compounds (VOCs), has become necessary in numerous sectors such as environmental management and health. The ability to measure low VOC concentrations could enable precise tracking of atmospheric pollutants, or biomarkers in breath for non-invasive medical screening. Fourier Transform Infrared (FTIR) spectroscopy has facilitated the detection of those organic gases, by measuring their absorbance in the infrared electromagnetic spectrum. However, conventional spectrometers are limited in the mid-infrared (MIR) region, from 2 to 20 µm, due to important shortcomings of current classical sources and detectors. Recently, quantum FTIR (QFTIR) spectroscopy [1,2] was proposed as a way of bypassing these limitations, by leveraging of induced coherence [3] and spectral correlations in non-degenerate photon-pairs produced by Spontaneous Parametric

Down-Conversion (SPDC). The combination of those two quantum phenomena in a so-called nonlinear Michelson interferometer allows to retrieve a broad mid-infrared spectrum, by measuring a near-infrared field alone, thus removing the need for MIR sources and detectors. Yet, further work is needed to properly assess QFTIR's applicability in practical outdoor setting. Our work marks an important milestone in this context as it first demonstrates the fast open-path detection of multiple interfering organic gases in ambient air thanks to a quantum FTIR spectrometer. We built a nonlinear Michelson interferometer coupled with analysis techniques from classical differential absorption spectroscopy used for gas-traces detection. We characterized our spectrometer's sensitivity by detecting methane and butane spectra. We showed this characteristic is preserved over time by performing measurements of gasses mixtures overnight [4]. We also measured butane's spectrum in ambient air with an integration time of 36 seconds, thus demonstrating the accurate and fast identifications of organic gases. These results represent a significant step toward real-time QFTIR detection systems suitable for practical environmental and industrial monitoring applications.

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Quantum generation of stochastic processes: spectral invariants and memory bounds.
Magdalini Zonnios (Trinity College Dublin).

Abstract. Stochastic processes abound in nature and accurately modeling them is essential across the quantitative sciences. They can be described by hidden Markov models or by their quantum extensions. These models explain and give rise to process outputs in terms of an observed system interacting with an unobserved memory. Although there are infinitely many models that can generate a given process, they can vary greatly in their memory requirements. It is therefore of great fundamental and practical importance to identify memory-minimal models. This task is known to be hard in general, due to both the number of generating models, and the lack of invariant features that determine elements of the set. In general, it is forbiddingly difficult to ascertain that a given model is minimal. Addressing this challenge, we here identify spectral invariants of a process that can be calculated from any model that generates it. This allows us to determine strict bounds on the quantum generative complexity of the process—its minimal memory requirement. We then show that the bound is raised quadratically when we restrict to classical operations. This is an entirely quantum-coherent effect, as we express precisely, using the resource theory of coherence. Finally, we demonstrate that the classical bound can be violated by quantum models.

Memory-based quantum networks: prospects, challenges, and new efforts in Florence.
Emanuele Distante (University of Florence/LENS), Maximilian Schemmer (CNR - National Institute of Optics / LENS), Natalia Bruno (CNR - National Institute of Optics / LENS), Stephan Welte (5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart,), Lukas Hartung (Max-Planck-Institute of Quantum Optics), Matthias Seubert (Max-Planck-Institute of Quantum Optics) and Gerhard Rempe (Max-Planck-Institute of Quantum Optics).

Abstract. While many quantum technologies, such as computing, sensing, and communication, are reaching maturity and transitioning from academic to industry, a key long-term goal that remains an open challenge is the realization of a large-scale quantum internet — a global network of quantum devices that exchange quantum information via light. Such a network could enable powerful distributed quantum computation, high-precision clock synchronization, and fundamentally secure long-distance communication. The envisioned architecture relies on quantum memories—matter-like qubits at each network node—that can reliably store and process quantum information carried by optical photons. These photons transmit information and entanglement between nodes through optical fibers, but losses in the fiber limit the communication distance. To overcome this, it is essential to develop quantum memories compatible with telecom wavelengths and implement quantum repeaters. Much like their classical counterparts, quantum repeaters extend the reach of the network by enabling long-distance entanglement distribution. A deployable and functional quantum repeater node is a key element that would unlock the possibility of realizing the envisioned large-scale Quantum Internet. In this talk, I will give an overview of recent efforts toward memory-based quantum networks, specifically focusing on a platform based on single atoms in optical cavities that we used to realize a rudimentary quantum network link [1], and a highly efficient, multiplexed quantum memory node based on an atomic array in an optical cavity [2]. I will then present a new experimental platform under development in Florence, which uses single ytterbium atoms trapped in optical tweezers and coupled to an optical cavity. By exploiting a telecom-compatible transition in ytterbium and the exceptional coherence properties of its clock states, our goal is to realize a quantum repeater node capable of interfacing long-lived atomic qubits with narrowband telecom photons. I will discuss the motivations for this approach, the current status of the experiment, and its potential impact for building scalable, memory-based quantum networks.

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Current fluctuations in open quantum systems beyond weak coupling.

Khalak Mahadeviya (Trinity College Dublin), Saulo V. Moreira (Trinity College Dublin), Sheikh Parvez Mandal (Universidad de Murcia), Mahasweta Pandit (Universidad de Murcia), Javier Prior (Universidad de Murcia) and Mark T. Mitchison (King's College London).

Abstract. Currents in nanoscale nonequilibrium systems are inherently stochastic, and their fluctuations can significantly impact the performance of quantum devices. With recent advances in quantum technologies, there is a growing need to investigate open quantum systems beyond the conventional weak-coupling and Markovian limits. Here, we study current fluctuations in a coherently driven qubit strongly coupled to a structured bosonic environment. By combining full counting statistics with the reaction coordinate mapping, we develop a framework that enables the calculation of steady-state current fluctuations and their temporal correlations in the strong-coupling regime. We find that, in contrast to weak coupling, both the average current and its fluctuations exhibit a non-monotonic dependence on the system–environment interaction strength. Notably, we identify a regime where current noise is suppressed below the classical thermodynamic uncertainty bound, accompanied by enhanced anticorrelations in quantum jump trajectories and faster relaxation dynamics. We further show that these features are linked to nonclassical properties of the reaction coordinate mode, including non-Gaussianity and quantum coherence. Our results provide new insights and design principles for control-

ling current fluctuations in quantum devices operating beyond the standard weak-coupling paradigm.

Concentration of ergotropy in many-body systems.

Karen Hovhannisyan (University of Potsdam), Rick Simon (University of Exeter) and Janet Anders (University of Potsdam).

Abstract. Ergotropy — the maximal amount of unitarily extractable work — quantifies the “charge level” of a quantum battery. We prove that, in large many-body batteries, it exhibits a concentration of measure phenomenon. Namely, the ergotropy almost coincides with its average for almost all states sampled from the Hilbert–Schmidt measure. Remarkably, this average is macroscopic: it scales with the number of particles in the system. This occurs despite the von Neumann entropy also concentrating around a macroscopic average. We establish this by proving that ergotropy, as a function of the state, is Lipschitz-continuous with respect to the Bures distance, and by applying Lévy's measure concentration lemma. We numerically extend these results to the Bures measure, which represents the situation with the least amount of prior information about the state. Our continuity and concentration bounds open a new perspective on the noise-robustness of quantum many-body batteries and lay the groundwork for further rigorous studies of their charge stability and work extraction with limited prior knowledge.

New quantum machine learning models: Quantum Random and Dynamical Random Features.

Akitada Sakurai (Okinawa Institute of Science and Technology), Aoi Hayashi (Graduate University for Advanced Studies, SOKENDAI), William Munro (Okinawa Institute of Science and Technology) and Kae Nemoto (Okinawa Institute of Science and Technology).

Abstract. Quantum machine learning (QML) models often require deep circuits and optimization to access a broad range of frequency components. A few years ago, we introduced Quantum Extreme Reservoir Computing (QERC), demonstrating it can achieve about 97% test accuracy on the MNIST dataset with 10 qubits. It does not need any optimization in the quantum part. To encode image input into a small qubit system, it employs principal component analysis for dimensionality reduction. In this poster, we present Quantum Random Features and Quantum Dynamical Random Features. This model extends Random Fourier Features from classical machine learning to quantum models without requiring complex dimensional reduction typical of conventional quantum models, enabling efficient implementation on current quantum experimental devices.

Defocus effects in undetected photons imaging with momentum configuration: experiment and new theoretical framework.

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Abstract. The undetected-photon (UP) configuration is a key quantum imaging technique because it relaxes detector requirements compared with coincidence-based schemes. Spatial information about a sample probed by one photon is retrieved by detecting only its partner, which never interacts with the sample. Quantum imaging with undetected photons exploits two main effects: spatial correlations (in position or momentum) and induced coherence without induced emission [1]. Its versatility for spatially multimode operation has enabled video-rate imaging [2], Fourier-transform spectroscopy [3],

and holographic schemes [4,5]. Because UP setups typically employ photon-pair sources based on spontaneous parametric down-conversion (SPDC), their ultimate resolution has been investigated by tuning key parameters such as photon wavelengths [6] and crystal length [7]. However, practical implementation issues have been addressed only in a few cases: Ref. [8] introduced a photon-rate equalization scheme expected to enhance UP performance, and Ref. [9] examined magnification effects in a position-imaging configuration caused by slight object misalignments. Momentum-imaging configurations are expected to offer greater tolerance to sample positioning, yet a quantitative analysis of alignment tolerances is still missing. Ref. [10] qualitatively described different scenarios using extreme misalignment cases. Here, we present the first systematic analysis of how UP performance is affected by defocus in the sample path of a momentum-configuration, quantified via the interference visibility.
We report experimental results in good agreement with our new theoretical framework that relies on fewer approximations than previous treatments. Our model employs a double-Gaussian description of the SPDC photon source and explicitly accounts for finite crystal lengths as a key source parameter. Finally, we qualitatively investigate how the imaging resolution of an edge object is modified compared with direct imaging, providing practical guidelines for the robust alignment of momentum UP systems.
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Experimental memory control in continuous variable optical quantum reservoir computing.

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Abstract. Forecasting complex processes requires efficient learning from temporal data. Reservoir computing platforms enable such learning with minimal training cost. Quantum reservoir computing (QRC) extends this framework into the quantum domain, offering promising capabilities for online, quantum-enhanced machine learning tailored to temporal tasks. As in the classical case, photonics provides a natural platform for QRC. However, implementing native memory capabilities in practical photonic quantum systems remains asignificant challenge. Here, we demonstrate a photonic QRC platform based on deterministically generated multimode squeezed states, exploiting spectral and temporal multiplexing in a continuous-variable (CV) setting with controllable fading memory. Data is encoded via programmable pump phase shaping in an optical parametric process and retrieved through mode-selective homodyne detection. Real-time memory is implemented through feedback via electro-optic modulation, and expressivity is boosted via spatial multiplexing. This architecture enables nonlinear temporal tasks, including parity check at different delays and chaotic signal forecasting. All results are supported by a high-fidelity digital twin. Leveraging the entangled multimode structure enhances expressivity and memory capacity, establishing a scalable CV photonic platform for quantum-enhanced information processing.

Non-Degenerate Photonic Sources for Entanglement-Based Quantum Networks.

Ioanna Katsavou (Sorbonne Université), Huazhuo Dong (Sorbonne Université), Priyanka Giri (Sorbonne Université), Lucas Aoyagi (Sorbonne Université), Iliana Tsoni (Sorbonne Université), Eleni Diamanti (Sorbonne Université), Alban Urvoy (Sorbonne Université) and Julien Laurat (Sorbonne Université).

Abstract. Quantum repeater architectures rely on both the generation and the storage of entangled photon pairs, yet most quantum memories are intrinsically incompatible with telecom wavelengths. To overcome this challenge, entanglement between quantum memories via telecom heralding can be obtained by using frequency non-degenerate photon-pair sources. We developed cavity-enhanced spontaneous parametric down-conversion sources engineered for full compatibility with Rubidium (Rb) cold-atom quantum memories and fiber-based telecom networks. Each source produces a narrowband photon at 795 nm, resonant with the Rb D_1 transition, together with a telecom photon at 1608 nm, a low-loss wavelength ideal for long-distance transmission. The triply resonant cavity architecture ensures ultra-low pump-power operation, precise atomic-bandwidth matching, and high in-fiber heralding efficiency, exceeding 60%, directly increasing the achievable rates in quantum networking protocols. Within the framework of the European Quantum Internet Alliance project, the sources will be interfaced with quantum memories in a quantum repeater scheme, utilizing the 50 km Paris-region testbed.

Single-site diagonal quantities capture off-diagonal quasi-long-range order.

Marina Sanino (OIST), Irene D'Amico (University of York), Vivian Vanessa França (UNESP) and Isaac Martins Carvalho (ICTP).

Abstract. It is commonly believed that quantum phase transitions into off-diagonal long-range order phases, such as superconducting states, cannot be captured by diagonal single-site measures. We challenge this view by showing that local quantities — specifically charge and spin fluctuations — and the entanglement entropy, all computed at the central site of a one-dimensional extended Hubbard chain, exhibit clear critical behavior at the superconducting transition. In addition, we establish a direct and nontrivial connection between local observables and nonlocal quantum correlations, which remains robust even under weak breaking of local particle–hole symmetry. These findings show how superconducting transitions may be detected through strictly local information.

Engineering open quantum systems via large deviation methods.

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Abstract. The dynamics of an open quantum system can be characterized by a stochastiic process, where a pure state continuously evolves and its dynamics is interrupted by quantum jumps, such as spontaneous photon emissions. Each experimental realization yields a quantum jump trajectory and the statistics of an ensemble of

such trajectories can be characterised by large deviations theory. This theory describes the full probability distribution of stochastic observables in the limit of long dynamics times and quantifies the probability of rare dynamical fluctuations that deviate from the typical value. A key tool in this context is the Doob transform, which allows rare dynamical events to be studied by mapping them onto the typical behaviour of an auxiliary system. In this work, we focus on explicitly constructing these Doob-transformed dynamics using perturbation techniques in a many-body open quantum system. Our results provide analytical insight into the structure of rare trajectories and point toward practical strategies for engineering quantum devices that make usage of rare dynamical behaviour as a resource.

Toward the Integration of a Two-Dimensional Coulomb Crystal into a Bow-Tie Optical Cavity.

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Abstract. Trapped ions, when laser-cooled to ultralow temperatures, crystallize into ordered structures due to their mutual Coulomb repulsion. Their exceptional isolation from the environment and the high degree of individual control make them an ideal platform for studying quantum many-body physics and cavity quantum electrodynamics. We laser-cool barium ions to form Coulomb crystals and observe dimensional structural transitions from one-dimensional linear chains to two-dimensional ordered configurations [1] [2]. Building on this work, our next objective is to couple the ion Coulomb crystal to a running wave bow-tie optical cavity. Unlike a Fabry–Perot cavity, where the standing-wave field leads to position-dependent coupling and vanishing interaction at field nodes, a bow-tie cavity provides uniform coupling strength for all ions along the cavity mode,thus enabling an optimal collective coupling between the entire ion crystal and an optical mode. Our system operates in the intermediate coupling regime of cavity QED, which is particularly appeal- ing as it enables both efficient photon emission into the cavity mode and photon-mediated interactions between the ions. Our system aims at demonstrating a new geometry for ion-cavity coupling and ion- photon interaction. Moreover, we aim at using the cavity to realize deep optical potentials to confine two-dimensional crystals of ions.

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Coherent SiV center in Diamond nanophotonic waveguide for Quantum information.
Althéa Housset (Laboratoire Kastler Brossel,Paris, France).

Abstract. Single photon sources of different types have been widely studied in the past years for quantum information. However, collecting efficiently their single photon emission remains a challenge. Solid-state single photon sources can be compact compared to traditional atomic systems, and can be integrated in photonic chips. Our work focuses on theoretical coupling of a diamond nanowaveguide with embedded group IV-color centers and specifically silicon vacancy (SiV) centers, to a nanofiber (cf. figure1). Optical nanofibers, with their sub-wavelength diameters, can interact with their surrounding environment through an evanescent field at their surface. We can therefore perform an adiabatic transfer of the single photons with tapers on both ends of the diamond nanowaveguide, to ensure a smooth transition between the two eigenstates, without incurring energy losses through change in the eigenvalue [1][2]. We developed a pick-and-place setup and technique for the deposition of the waveguide onto the nanofiber. As at low temperatures, the quality and directionality of emitted photons are significantly improved, we will proceed with the integration of the platform into a cryostat at 3K. Future studies will consider other shapes of waveguides[3] as well as focusing on exploring interactions such as giant nonlinearities between single photons and quantum emitters[4]to develop a functional optical control switch for single-photons.
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Who gets the quantum budget?
Giovanna Badalassi (Gender budgeting expert and Ladynomics)

Abstract. In quantum physics, as across the broader research landscape, financial structures do far more than sustain scientific activity: they shape hierarchies of influence, define access to opportunities, and subtly guide institutional priorities. Funding is not neutral—it is a vector of prestige and decision-making power. Within this framework, gender equality cannot be treated solely as a cultural or ethical objective; it must also be understood as an economic and governance issue embedded in how resources are allocated, monitored, and evaluated. This contribution explores how financial literacy and transparency can become strategic tools for advancing gender balance in research institutions. By developing the ability to critically interpret institutional budgets, project funding schemes, and allocation mechanisms, researchers and administrators alike can uncover how financial flows impact career trajectories, working conditions, and well-being. At the same time, these dynamics influence the very nature of scientific outputs and outcomes, including their inclusivity, relevance, and societal impact.
The talk introduces key concepts at the intersection of gender equality and financial governance, with particular attention to the role of gender budgeting in research environments. It presents selected practices adopted by research institutions to integrate gender-sensitive indicators into financial planning and evaluation processes. Special emphasis is placed on the use of gender equality KPIs as analytical and operational tools—ca-

pable not only of highlighting disparities but also of informing more effective and equitable decision-making.
Focusing on the context of quantum physics, the discussion argues that diversity within research teams is not merely a matter of representation, but a driver of scientific quality, innovation, and impact. By aligning financial strategies with gender equality objectives, institutions can enhance both the fairness of career systems and the overall effectiveness and efficiency of research outcomes.

Quantum Ambassadors: Bringing Quantum Physics into the Classroom
Marta Domínguez-Navarro (Insitut de Ciències del Cosmos Universitat de Barcelona (ICCUB))

Abstract. Quantum Ambassadors is an outreach and education initiative led by the Institut de Ciències del Cosmos (ICCUB) and the Institut de Nanociència i Nanotecnologia (IN2UB) of the Universitat de Barcelona, in collaboration with the Catalonia Quantum Academy (CQA), the Faculty of Physics, and IDP-ICE. Launched in July 2025, it brings together university researchers and secondary school teachers from over 30 schools across Catalonia in a year-long collaboration to make quantum physics accessible and inspiring at the pre-university level.
Two project technicians develop classroom materials and deliver talks, while researchers provide guidance and run quantum mechanics training sessions for teachers. Teachers, as Quantum Ambassadors, pilot the materials and provide feedback, creating an iterative process that ensures accuracy and pedagogical effectiveness.
The resources include interactive simulations and video games developed by undergraduate Physics students through the Quantum UB Lab platform. Selected students, called Quantum Representatives, participate in lab visits, the annual Quantum Physics Masterclass, and a closing symposium. The first school visits to implement these materials took place in early 2026, marking the beginning of the students' direct engagement with the program.
Beyond knowledge transfer, Quantum Ambassadors aims to spark scientific curiosity, engage students who might not otherwise explore physics, challenge stereotypes about who belongs in science, and show that quantum physics is for everyone. With both of the project's lead coordinators being women, and actively engaging with students, the project also serves as a visible example, demonstrating that physics is inclusive and accessible to all, while providing inspiration for girls in the classroom.

QPlayLearn: tools for a broader quantum literacy
Cecilia Chiaracane (QPlayLearn - Algorithmiq)

Abstract. By challenging our intuitions about reality, quantum physics opens space for radically new ideas, innovative technologies, and unconventional perspectives. As quantum technologies move beyond research labs to enter everyday life, it becomes increasingly important to develop a multifaceted quantum literacy.
QPlayLearn is an online platform that addresses this challenge by providing accessible, playful, yet rigorous resources on quantum science and technology. Created by quantum physicists passionate about outreach and education, the project is grounded in the belief that anyone, regardless of age and background, can learn about quantum physics and its applications.
The platform offers diversified content for multiple audiences, from primary school to university physics students, curious learners, professionals in industry, and policy makers. This flexibility allows the platform to support both self-paced learning and integration into formal educational contexts.
We will introduce the educational approach behind QPlayLearn and highlight the newest resources on the platform.