Quantum Science Generation | QSG

Report of Contributions

Contribution ID: **13** Type: **Talk**

Can deep sub-wavelength cavities induce Amperean superconductivity in a 2D material?

Tuesday, 2 May 2023 14:30 (30 minutes)

Amperean superconductivity is an exotic phenomenon stemming from attractive effective electron-electron interactions (EEEIs) mediated by a transverse gauge field. Originally introduced in the context of quantum spin liquids and high-Tc superconductors, Amperean superconductivity has been recently proposed to occur at temperatures on the order of 1-20 K in two-dimensional, parabolic-band, electron gases embedded inside deep sub-wavelength optical cavities. In this talk, I first generalize the microscopic theory of cavity-induced Amperean superconductivity to the case of graphene and then argue that this superconducting state cannot be achieved in the deep sub-wavelength regime. In the latter regime, indeed, a cavity induces only EEEIs between density fluctuations rather than the current-current interactions which are responsible for Amperean pairing.

Abstract category

Other

Primary author: ANDOLINA, Gian Marcello (College de France, Paris.)

Presenter: ANDOLINA, Gian Marcello (College de France, Paris.)

Contribution ID: **15** Type: **Talk**

Programmable distribution of multi-qubit entanglement in dual-rail waveguide QED

Wednesday, 3 May 2023 15:30 (30 minutes)

We investigate the autonomous generation of multi-partite entangled states in a dual-rail waveguide QED configuration. Here, qubits arranged along two separated photonic waveguides are illuminated by the output of a nondegenerate parametric amplifier, which drives them into a strongly correlated steady state. We show that in this setup, there exists a large family of pure steady states, for which the connectivity and the degree of multi-qubit entanglement can be selectively adjusted by simply changing the applied pattern of qubit-photon detunings. This offers intriguing new possibilities for distributing ready-to-use multi-partite entangled states across large quantum networks, which do not require any precise pulse control and rely on Gaussian entanglement sources only.

Abstract category

Quantum Optics

Primary author: AGUSTI, Joan (Walther-Meißner-Institut)

Co-authors: FINK, Johannes M. (ISTA); RABL, Peter (TU Wien); MINOGUCHI, Yuri (TU Wien)

Presenter: AGUSTI, Joan (Walther-Meißner-Institut)

Contribution ID: **16** Type: **Talk**

Analysing crosstalk with the digital twin of a Rydberg atom QPU

Friday, 5 May 2023 11:00 (30 minutes)

Decoherence and crosstalk are two adversaries when aiming to parallelize a quantum algorithm: on the one hand, the execution of gates in parallel reduces decoherence due to a shorter runtime, but on the other hand, parallel gates in close proximity are vulnerable to crosstalk. This challenge is visible in Rydberg atom quantum computers where atoms experience strong van der Waals interactions decaying with distance. We demonstrate how the preparation of a 64-qubit GHZ state is affected by crosstalk in the closed system with the help of a tensor network digital twin of a Rydberg atom QPU. Then, we compare the error from crosstalk to the decoherence effects proving the necessity to parallelize algorithms.

Abstract category

Quantum Computing

Primary author: PAGANO, Alice (University of Padova)

Co-authors: Dr JASCHKE, Daniel (University of Ulm); Dr WEBER, Sebastian (University of Stuttgart); Prof. MONTANGERO, Simone (University of Padova)

Presenter: PAGANO, Alice (University of Padova)

Contribution ID: **17** Type: **Poster.**

Tree Tensor Networks for quantum many-body systems at finite temperature

We develop and implement an efficient Tree Tensor Network based algorithm for computing the finite temperature many-body density matrix. This approach is particularly important because, since physical systems can never be cooled down to absolute zero temperature, a complete description of the physics behind the quantum computing devices has to account for finite temperature effects. However, the finite temperature, i.e. mixed state scenario, represents an additional challenge in comparison to the already computationally demanding zero-temperature quantum many-body simulations. For low-dimensional lattice systems, various applications have demonstrated that tensor network methods are a powerful numerical tool, extending possible simulations to a large number of particles. We present the numerical techniques for computing the purity, Von Neumann entropy, Rényi entropies of any order, negativity, and entanglement of formation for the mixed state systems. Our approach is successfully applied to one-dimensional quantum Ising model, and moreover, to the systems of neutral Rydberg atoms trapped in the optical tweezer arrays, representing a physical quantum computing and simulation platform.

Abstract category

Numerical Methods

Primary author: REINIĆ, Nora (University of Padova, INFN)

Co-authors: JASCHKE, Daniel (University of Ulm); SILVI, Pietro (University of Padova); MONTANGERO, Simone (University of Padova)

Presenter: REINIĆ, Nora (University of Padova, INFN)

Contribution ID: **18** Type: **Talk**

The bosonic skin effect: boundary condensation in asymmetric transport

Friday, 5 May 2023 14:00 (30 minutes)

We study the incoherent transport of bosonic particles through a one dimensional lattice with different left and right hopping rates, as modelled by the asymmetric simple inclusion process (ASIP). Specifically, we show that as the current passing through this system increases, a transition occurs, which is signified by the appearance of a characteristic zigzag pattern in the stationary density profile near the boundary. In this highly unusual transport phase, the local particle distribution alternates on every site between a thermal distribution and a Bose-condensed state with broken U(1)-symmetry. Furthermore, we show that the onset of this phase is closely related to the so-called non-Hermitian skin effect and coincides with an exceptional point in the spectrum of density fluctuations. Therefore, this effect establishes a direct connection between quantum transport, non-equilibrium condensation phenomena and non-Hermitian topology, which can be probed in cold-atom experiments or in systems with long-lived photonic, polaritonic and plasmonic excitations.

Abstract category

Quantum Optics

Primary authors: GARBE, Louis (TU Wien); MINOGUCHI, Yuri (TU Wien); Dr HUBER, Julian (TU Wien); RABL, Peter (TU Wien)

Presenter: GARBE, Louis (TU Wien)

Contribution ID: **19** Type: **Poster**

Electromagnetically induced acoustic transparency amplifier using a superconducting transmon circuit

We present a scheme for the amplification of electromagnetically induced acoustic transparency (EIAT) in a superconducting transmon circuit. Recently, EIAT has been demonstrated experimentally
in a three-level ladder-type superconducting artificial atom [G Andersson et al, Phys. Rev. Lett. 124,
240 402 (2020)]. In this experiment, the authors have noticed only 20% transmission of surface acoustic waves (SAW) due to limited linewidth of the EIT window. Here we utilize an additional microwave field to enhance the transmission of SAW. This additional field increases the coherence in
the second excited state which causes the amplification in transmission and the reduction in corresponding group velocity is achieved.

Abstract category

Quantum Optics

Primary author: BATOOL, Syeda Aliya (Research Assistant at TU Wien, Austria)

Co-authors: Mr ULLAH, Rahmat (Assistant Professor, COMSATS University Islamabad); Prof. QAMAR, Sajid (Dean of Sciences, COMSATS University Islamabad.)

Presenter: BATOOL, Syeda Aliya (Research Assistant at TU Wien, Austria)

Contribution ID: **20** Type: **Poster.**

Purified subspace-search variational quantum eigensolver

Variational quantum algorithms (VQA) are mainly designed to obtain an approximation for the ground state of a target Hamiltonian. Methods based on VQA for calculating excited states currently involve high-depth unitary implementation or state-specific optimizations on top of previously-found ground states. To directly extend the VQA framework to excited states, we propose an algorithm based on our recent purification of weighted ensemble states [1]. This algorithm uses the Gross-Oliveira-Kohn variational principle used in excited-state density functional theories and chooses the appropriate set of weights to construct a Bardeen-Cooper-Schrieffer (BCS)-like state in a well-defined duplicated Hilbert space. The exponential form of such a BCS-like state allows a quite efficient implementation of a VQA for excited states on near-term quantum devices. Combining a variational quantum circuit and a neural network, our algorithm can obtain, for finite Hamiltonians, all the excited states we want.

[1] C. L. Benavides-Riveros et al., Phys. Rev. Lett. 129, 066401 (2022).

Abstract category

Quantum Computing

Primary author: BENAVIDES-RIVEROS, Carlos L. (Università di Trento)

Presenter: BENAVIDES-RIVEROS, Carlos L. (Università di Trento)

Contribution ID: **21** Type: **Poster.**

Squeezing and Quantum Approximate Optimization

Variational quantum algorithms offer fascinating prospects for the solution of combinatorial optimization problems using digital quantum computers. However, the achievable performance in such algorithms and the role of quantum correlations therein remain unclear. Here, we shed light on this open issue by establishing a tight connection to the seemingly unrelated field of quantum metrology: Metrological applications employ quantum states of spin-ensembles with a reduced variance to achieve an increased sensitivity, and we cast the generation of such squeezed states in the form of finding optimal solutions to combinatorial problems (e.g., MaxCut) with increased precision. On the one hand, by solving this optimization problem with a quantum approximate optimization algorithm (QAOA), we show numerically as well as on an IBM quantum chip, how highly squeezed states are generated in a systematic procedure that can be adapted to a wide variety of quantum machines. On the other hand, squeezing tailored for the QAOA of the MaxCut relates to quantum correlation in the form of entanglement, it permits us to propose a figure of merit for future hardware benchmarks, and it can resource-effectively boost the averaged final energy of QAOA optimization obtained in MaxCut of random graph instances. Further exploitation of this connection between metrology and optimization may uncover solutions to prevailing problems and push the scope of precision in both fields.

Abstract category

Quantum Computing

Primary author: Mr SANTRA, Gopal Chandra (Universität Heidelberg, Germany & University of Trento, Italy)

Co-authors: Dr EGGER, Daniel J. (IBM Quantum, IBM Research Europe –Zurich); Dr JENDRZEJEWSKI, Fred (Universität Heidelberg, Kirchhoff-Institut für Physik); Dr HAUKE, Philipp (Pitaevskii BEC Center and Department of Physics, University of Trento)

Presenter: Mr SANTRA, Gopal Chandra (Universität Heidelberg, Germany & University of Trento, Italy)

Contribution ID: **22** Type: **Talk**

Process Tensor Networks for non-Markovian Many-Body Open Quantum Systems

Wednesday, 3 May 2023 12:00 (30 minutes)

There is a range of interesting physical scenarios that include both many-body quantum systems *and* strongly coupled structured environments that lead to a non-Markovian evolution. However, almost all methods for the study of many-body systems only consider closed or Markovian dynamics, while methods for the study of non-Markovian open quantum systems are generally restricted to small system sizes. I will introduce a general numerical method to compute dynamics and multi-time correlations of chains of quantum systems, where each system may couple strongly to a structured environment [1,2]. The method combines the process tensor formalism for general (possibly non-Markovian) open quantum systems with time evolving block decimation (TEBD) for 1D chains. It systematically reduces the numerical complexity originating from system-environment correlations before integrating them into the full many-body problem, making a wide range of applications numerically feasible. Furthermore, on a more conceptional side, I will discuss fundamental connections among the concept of Markovianity, multi-time correlations, and the dynamics of a many-body open quantum system [3]. These connections not only have far reaching consequences in, for example, the field of strong coupling quantum thermodynamics, but also in many-body scenarios that are usually considered to be Markovian in the literature.

[1] G. E. Fux, D. Kilda, B. W. Lovett, and J. Keeling, *Thermalization of a spin chain strongly coupled to its environment*, arXiv:2201.05529 (2022).
[2] The TEMPO Collaboration, *OQuPy: A Python 3 package to efficiently compute non-Markovian open quantum systems*, ReadTheDocs (2020).
[3] G. E. Fux, *Operationally accessible information backflow in CP-divisible processes*, in preperation.

Abstract category

Numerical Methods

Primary author: FUX, Gerald E. (International Center for Theoretical Physics)

Co-authors: Dr KILDA, Dainius (Max-Planck-Institut für Quantenoptik); Prof. LOVETT, Brendon W. (University of St Andrews); Dr KEELING, Jonathan (University of St Andrews)

Presenter: FUX, Gerald E. (International Center for Theoretical Physics)

Contribution ID: **23** Type: **Talk**

Superconducting qubits and propagating microwave photons

Tuesday, 2 May 2023 10:00 (1 hour)

In this talk I will discuss how it is possible to perform quantum information tasks in superconducting quantum devices using microwave guides and propagating photons. In the first half of the talk I will discuss how superconducting qubits couple to microwave guides, implementing canonical models of quantum optics and condensed matter physics. This includes both strong and ultrastrong coupling regimes, as well as quantum phase transitions, all of which can be studied with analytical and numerical techniques. In the second half of the talk, I will discuss how these setups can be used to implement quantum state transfer between superconducting quantum processors, and how these ideas can be used implementing quantum gates. I will discuss the limits of fidelity and speed, how to improve the transfer correcting for photon dispersion, or how to multiplex the transfer.

Abstract category

Quantum Computing

Primary author: GARCÍA RIPOLL, Juan José (Institute of Fundamental Physics, CSIC)

Presenter: GARCÍA RIPOLL, Juan José (Institute of Fundamental Physics, CSIC)

Contribution ID: **25** Type: **Talk**

Hassle-free Extra Randomness from quantum state's identicalness with untrusted components

Friday, 5 May 2023 12:00 (30 minutes)

This paper investigates a semi-device-independent protocol for quantum randomness generation constructed on the prepare-and-measure scenario based on the on-off-keying encoding scheme and with various detection methods, i.e., homodyne, heterodyne, and single photon detection schemes. The security estimation is based on lower bounding the guessing probability for a general case and is numerically optimized by utilizing semi-definite programming. Additionally, a practical, easy-to-implement optical setup is presented, which can be implemented via commercial off-the-shelf components.

Abstract category

Numerical Methods

Primary author: TEBYANIAN, Hamid (University of York)

Presenter: TEBYANIAN, Hamid (University of York)

Contribution ID: **26** Type: **Poster.**

A novel approach to noisy gates for simulating quantum computers

We present a novel method for simulating the noisy behaviour of quantum computers, which allows to efficiently incorporate environmental effects in the driven evolution implementing the gates on the qubits. We show how to modify the noiseless gate executed by the computer to include any Markovian noise, hence resulting in what we will call a noisy gate. We compare our method with the IBM Qiskit simulator, and show that it follows more closely both the analytical solution of the Lindblad equation as well as the behaviour of a real quantum computer, where we ran algorithms involving up to 18 qubits; thus, it offers a more accurate simulator for NISQ devices. The method is flexible enough to potentially describe any noise, including non-Markovian ones. The noise simulator based on this work is available as a python package at this link: https://pypi.org/project/quantum-gates/

Abstract category

Quantum Computing

Primary authors: BASSI, Angelo (University of Trieste); Mr CESA, Francesco (University of Trieste); Mr DI BARTOLOMEO, Giovanni (University of Trieste); Dr GROSSI, Michele (European Organization for Nuclear Research (CERN)); VISCHI, Michele (University of Trieste); Mr WIXINGER, Roman (Institute of Particle Physics and Astrophysics, ETH Zurich); DONADI, Sandro (Istituto Nazionale di Fisica Nucleare, Trieste Section, Via Valerio 2, 34127, Trieste, Italy)

Presenters: Mr DI BARTOLOMEO, Giovanni (University of Trieste); VISCHI, Michele (University of Trieste)

Contribution ID: **27** Type: **Poster**

A novel approach to noisy gates for simulating quantum computers

We present a novel method for simulating the noisy behaviour of quantum computers, which allows to efficiently incorporate environmental effects in the driven evolution implementing the gates on the qubits. We show how to modify the noiseless gate executed by the computer to include any Markovian noise, hence resulting in what we will call a noisy gate. We compare our method with the IBM Qiskit simulator, and show that it follows more closely both the analytical solution of the Lindblad equation as well as the behaviour of a real quantum computer, where we ran algorithms involving up to 18 qubits; thus, it offers a more accurate simulator for NISQ devices. The method is flexible enough to potentially describe any noise, including non-Markovian ones. The noise simulator based on this work is available as a python package at this link: https://pypi.org/project/quantum-gates/

Abstract category

Quantum Computing

Primary authors: BASSI, Angelo (University of Trieste); CESA, Francesco (University of Trieste); DI BARTOLOMEO, Giovanni (University of Trieste); GROSSI, Michele (European Organization for Nuclear Research (CERN)); VISCHI, Michele (University of Trieste); WIXINGER, Roman (Institute of Particle Physics and Astrophysics, ETH Zurich); DONADI, Sandro (Istituto Nazionale di Fisica Nucleare, Trieste Section, Via Valerio 2, 34127, Trieste, Italy)

Presenters: DI BARTOLOMEO, Giovanni (University of Trieste); VISCHI, Michele (University of Trieste)

Contribution ID: **28** Type: **Talk**

Quantum kinetics of quenched two-dimensional Bose superfluids

Friday, 5 May 2023 15:00 (30 minutes)

We study theoretically the non-equilibrium dynamics of a two-dimensional (2D) uniform Bose superfluid following a quantum quench, from its short-time (prethermal) coherent dynamics to its long-time thermalization. Using a quantum hydrodynamic description combined with a Keldysh field formalism, we derive quantum kinetic equations for the low-energy phononic excitations of the system and characterize both their normal and anomalous momentum distributions. We apply this formalism to the interaction quench of a 2D Bose gas and study the ensuing dynamics of its quantum structure factor and coherence function, both recently measured experimentally. Our results indicate that in two dimensions, a description in terms of independent quasi-particles becomes quickly inaccurate and should be systematically questioned when dealing with non-equilibrium scenarios.

Abstract category

Numerical Methods

Primary author: DUVAL, Clément (Sorbonne Université)

Co-author: Mr CHERRORET, Nicolas (Sorbonne Université)

Presenter: DUVAL, Clément (Sorbonne Université)

Contribution ID: **29** Type: **Talk**

Driven-dissipative quantum many-body systems: From instability in cavity-boson systems to enhancement of superconductivity

Tuesday, 2 May 2023 12:00 (30 minutes)

The driven-dissipative nature of quantum optical many-body systems is conventionally captured by the Lindblad form. It leads to substantial distinctions from their static counterparts described by the same effective Hamiltonian, including, for example, the dissipative instability towards high energy states in cavity-boson systems. The combination of the Floquet and Keldysh theories provide a more profound understanding of the underlying mechanism. The developed technique captures the most essential ingredient in the core of all these effects: the relative system-bath rotation, in a way far more comprehensive than the Lindblad form. Particularly, it can be straightforwardly applied to condensed matter systems, and reveals more intriguing and unexplored physics. Specifically in the Hubbard-Stratonovich mean-field description of superconductors, we predict the driven-dissipative enhancement of the superconducting gap at finite temperatures comparable to and beyond the critical temperature.

Abstract category

Quantum Optics

Primary authors: Dr RAMIRES, Aline (Paul Scherrer Institute); Dr CHITRA, R. (ETH Zurich); LIN, Rui (ETH Zurich)

Presenter: LIN, Rui (ETH Zurich)

Contribution ID: **30** Type: **Talk**

Enhanced Cavity Optomechanics with Quantum-Well Exciton Polaritons

Tuesday, 2 May 2023 15:00 (30 minutes)

A key figure of merit in optomechanics is the single-photon quantum cooperativity (Cq). Recent works achieved a large cooperativity by engineering resonators with ultra-low mechanical and optical losses [1]. A complementary approach is to enhance optomechanical interactions while working with modest optical and mechanical quality factors. Less stringent bandwidth limitations in optomechanical conversion are thereby imposed [2], while suppressing optical heating and added noise [1].
In this context, GaAs- based resonators engineered to simultaneously confine photons, phonons and QW excitons offer an intriguing opportunity [3]: in the strong exciton-photon coupling regime the system hosts hybrid quasi-particles, or polaritons. These modes are both spectrally separated from the exciton-induced absorption peak, enabling large optical quality factors, while their excitonic component is extremely sensitive to strain fields owing to the large GaAs deformation potential, thus prospecting strong optomechanical interactions. We analytically model the tripartite interaction of light, QW excitons, and sound in three semiconductor microresonators architectures: when considering parameters complying with current GaAs technologies, we show that a near-unity Cq can be obtained for a single polariton excitation. Furthermore, we investigate how polariton nonlinearities modify dynamical back-action via squeezing [4].

[1] H. Ren, M. H. Matheny et al. - Nat. Comm. 11, 3373 (2020)
[2] Y.D. Wang and A.A. Clerk, PRL 108, 153603 (2012)
[3] G. Rozas, A.E. Bruchhausen et al. - PRB 90, 201302 (2014)
[4] N. Carlon Zambon, Z. Denis et al. PRL - 129, 093603 (2022)

Abstract category

Photonics

Primary authors: Dr CARLON ZAMBON, Nicola (ETH Zürich); Dr DENIS, Zakari (EPFL Lausanne); Dr DE OLIVEIRA, Romain (Université Paris Cité, CNRS, Paris); Dr RAVETS, Sylvain (Centre de Nanosciences et de Nanotechnologies (C2N), CNRS-Université Paris-Saclay, Palaiseau.); Prof. CIUTI, Cristiano (Université Paris Cité, CNRS, Paris); Prof. FAVERO, Ivan (Université Paris Cité, CNRS, Paris); Prof. BLOCH, Jacqueline (Centre de Nanosciences et de Nanotechnologies (C2N), CNRS-Université Paris-Saclay, Palaiseau)

Presenter: Dr CARLON ZAMBON, Nicola (ETH Zürich)

Contribution ID: **31** Type: **Poster**

Probing the acoustic modes of a levitated nanoparticle

Understanding and controlling light-matter interactions is a cornerstone of physics and an essential resource for quantum technologies, communication and metrology. Levitated nano-objects offer a new paradigm to study the interaction between electromagnetic fields and matter at the very interface between quantum optics and macroscopic electrodynamics [1]. What is intriguing about levitated objects in high vacuum is that they can interact with the outside world only via their coupling to the electromagnetic field, this both grants an exceptional isolation from the environment while optical fields can be used to precisely interrogate and manipulate the system. So far, research on levitated nano-objects has mainly focused on controlling the center-of-mass motion and rotational degrees of freedom [2-4]. However, nanoparticles also possess highly discretised vibrational modes in the GHz band [5]: such internal degrees of freedom, remain scarcely explored.

Here, we describe the coupling mechanism of the nanoparticle acoustic vibrations to the electromagnetic field and implement a two-tone optical spectroscopy technique, namely stimulated Brillouin scattering, to probe these modes. We characterize the capabilities of our experimental setup and discuss some preliminary results. If successful these experiments will enrich the levitodynamics toolbox and allow to study fundamental excitations in solids in the extreme scenario of unclamped matter at the nanoscale, in high vacuum and out of equilibrium.

[1] C. Gonzalez-Ballestero et al. Science 374, 6564 (2021).
[2] L. Magrini et al. Nature 595, 373-377 (2021)
[3] F. Tebbenjohanns et al. Nature 595, 378–382 (2021).
[4] F. van der Laan et al. PRL 127, 123605 (2021).
[5] M.H. Kuok et al. PRL 90, 255502 (2003)

Abstract category

Quantum Optics

Primary authors: Dr CARLON ZAMBON, Nicola (ETH Zürich); Dr VIJAYAN, Jayadev (ETH Zürich); Dr GONZALEZ-BALLESTERO, Carlos (Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria); Dr REIMANN, Rene (Quantum Research Centre, Technology Innovation Institute, Abu Dhabi); Dr FRIMMER, Martin (ETH Zürich); Prof. ROMERO-ISART, Oriol (Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck); Prof. NOVOTNY, Lukas (ETH Zürich)

Presenter: Dr CARLON ZAMBON, Nicola (ETH Zürich)

Contribution ID: **33** Type: **Talk**

Integrated photonics for trapped ion quantum computing

Thursday, 4 May 2023 12:00 (30 minutes)

Trapped ions are one of the most promising platforms in the field of quantum computing and simulation. Technology nowadays offers incredible tools to trap and manipulate individual particles down to the quantum level, but the current state of the art allows to maintain control of these systems only up to a certain size. One of the most pressing roadblocks to overcome is to make laser beam delivery scalable and efficient

On the other hand, integrated photonics is an established and powerful tool for manipulating laser light. Miniaturized optical elements can be precisely manufactured and replicated to scale, allowing control of light that wouldn't be possible with traditional bench-top free-space optics.

In this talk, I will introduce the current efforts to bridge these two technologies. Ion trapping experiments can take advantage of photonics for efficient addressing of ions with laser light, shaping light beams in order to tailor atom-light interactions, and integrating photonic structures directly in the trap as a way to scale from lab experiments to the next generation's computers.

Abstract category

Quantum Computing

Primary author: MORDINI, Carmelo (ETH Zurich - Institute for Quantum Electronics)

Presenter: MORDINI, Carmelo (ETH Zurich - Institute for Quantum Electronics)

Contribution ID: **36** Type: **Talk**

Towards a many-body atom-photon interface

Tuesday, 2 May 2023 12:30 (30 minutes)

Quantum networks have already been realized between two remote qubits. Our work aims to develop the ability to entangle remote quantum processors, each consisting of a register of qubits capable of universal quantum processing. On the path towards that, we have developed a small-scale trapped ion quantum processor that allows for each qubit to be entangled with a different propagating photon. Such photons could be used to entangle remote copies of the processor. We demonstrated the capabilities of our system in two different ways: by generating 3 entangled atom-photon pairs and then swapping the quantum state from the matter processor to light; and by scaling our approach to 10 qubits.

Abstract category

Presenter: Dr CANTERI, Marco

Contribution ID: **40** Type: **Talk**

Tensor network states for real materials

Wednesday, 3 May 2023 09:00 (1 hour)

Tensor network states are widely and very successfully used for the simulation of models of strongly correlated systems. These models are often an oversimplification of real materials. In this talk I will show how tensor network methods can be used in the context of combinations of density functional theory for realistic band structures and embedding methods such as the dynamical mean-field theory (DMFT) to describe real materials quantitatively, such as Hund's metals or materials with important spin-orbit coupling.

Abstract category

Presenter: Dr SCHOLLWÖCK, Ulrich (University of Munich)

Contribution ID: **41** Type: **Talk**

Linear dispersion with a tilt: analog black holes, electron lenses and Berry curvature effects

Wednesday, 3 May 2023 10:00 (30 minutes)

In this talk, I present our recent study about transport in Weyl semimetals with spatially varying nodal tilt profiles. We discuss two complementary approaches that characterise the electron flow: solutions of the semi-classical equations of motion, in analogy to those encountered in black hole spacetimes, and large-scale microscopic simulations of a scattering region surrounded by semi-infinite leads. We show that the two approaches lead to equivalent results when the wave packet is sufficiently far from the center of the tilt. The two methods are arguably a powerful toolset in the pursuit of tiltronic devices such as e.g. electronic lenses.

Abstract category

Presenter: Dr HALLER, Andreas (University of Luxembourg)

Contribution ID: **42** Type: **Talk**

Neural Quantum States for Many Body (dissipative) Quantum Dynamics

Wednesday, 3 May 2023 11:00 (30 minutes)

Neural network quantum states have delivered state of the art results for the calculation of ground states for systems beyond the reach of more conventional techiniques.
Such variational ansatzes have also been applied to the simulation of the dynamics of systems at equilibrium or far from it.
In this talk I will discuss recent advancements in the treatment of the dynamics with a particular focus on the dissipative dynamics of Markovian Open Quantum Systems.

Abstract category

Presenter: Dr VICENTINI, Filippo (Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL))

Contribution ID: **43** Type: **Talk**

Transport in the Asymmetric Simple Inclusion Process and an Unexpected Unification of Bosons and Fermions

Wednesday, 3 May 2023 11:30 (30 minutes)

We study the counting statistics of the asymmetric simple inclusion process (ASIP), which describes the dissipative transport of bosons along a one dimensional lattice. By combining exact numerical simulations with a field-theoretical analysis, we evaluate the current fluctuations for this process and determine their asymptotic scaling. Surprisingly, our findings show that the ASIP falls into the KPZ universality class and therefore, despite a drastic difference in the underlying particle statistics, exhibits the same scaling relations as the celebrated asymmetric simple exclusion process (ASEP) for fermions. We observe, however, crucial differences between the two processes in the shape of the distribution function, which we reconcile by mapping both models to the physics of one dimensional interfaces. This unified description shows that bosonic transport corresponds to interface growth, while its fermionic counterpart maps onto an eroding interface instead. Beyond their transport-theoretical interest, these fundamental relations can be probed in various experiments with cold atoms or with long-lived quasi-particles in nano-photonic lattices.

Abstract category

Presenter: MINOGUCHI, Yuri (TU Wien)

Contribution ID: **48** Type: **Talk**

The Quest of Quantum Advantage with a Hybrid Photonics Platform

Thursday, 4 May 2023 09:00 (1 hour)

Boson sampling is a computational problem that has been proposed as a candidate to obtain an unequivocal quantum computational advantage. The problem consists in sampling from the output distribution of indistinguishable bosons in a linear interferometer. There is strong evidence that such an experiment is hard to classically simulate, but it is naturally solved by dedicated photonic quantum hardware, comprising single photons, linear evolution, and photodetection. This prospect has stimulated much effort resulting in the experimental implementation of progressively larger devices. We will review recent advances in photonic boson sampling, describing both the technological improvements achieved and the future challenges. We will discuss recent proposals and implementations of variants of the original problem based on hybrid photonics platform.

Abstract category

Presenter: Prof. SCIARRINO, Fabio

Contribution ID: **49** Type: **Talk**

High-dimensional optical encodings for integrated error-protected Quantum Computing and Quantum Communication

Thursday, 4 May 2023 10:00 (30 minutes)

The control of large photonic integrated devices, processing tailored entangled resources of error-protected qubits, is an important step towards realising an all-photonic quantum computer. Measurement-based encodings, computing tasks and applications, showing improvements in such devices´ computational performance, will be shown. Furthermore, future perspectives on the advantages of the distribution of the above resource entangled states over chip-based quantum networks will also be discussed.

Presenter: Dr VIGLIAR, Caterina (Danmarks Tekniske Universitet)

Contribution ID: **50** Type: **Talk**

A real-time QRNG-to-QKD stream exploiting FPGA for high security Quantum Communication

Thursday, 4 May 2023 11:00 (30 minutes)

Most of the modern Quantum Key Distribution (QKD) and Quantum Random Number Generation (QRNG) systems require the usage of the Field Programmable Gate Array (FPGA) technology as it can guarantee the deterministic behavior necessary for dealing with qubit generation and readout. Nevertheless, the System-on-a-Chip (SoC) technology, which integrates both an FPGA and a CPU and allows for a very high level of flexibility, is not as common as the FPGA. Therefore, we exploited the SoC technology to realize a high performance QKD/QRNG system, implementing what we called "1-random-1-qubit"(QRN2Qubit) encoding. Such encoding grants a higher level of security, as each qubit is encoded with a unique random number. This is possible thanks to a real-time architecture that can continuously stream random data from a high speed QRNG (>300 Mbps) to a QKD transmitter (qubit repetition rate equal to 50 MHz) for BB84 protocol exploiting polarization degree of freedom of single photons. The system was tested for 55 hours and showed no interruptions and correctly delivered the data from the QRNG to the QKD transmitter. Most of the nowadays systems exploit a low-rate QRNG (few Mbit/s) and algorithm expansions to reach the required bitrate but with a major drawback in security as the transmitted qubit sequence is not fully random due to the expansion algorithms. Thus, this system offers a higher level of security for QKD thanks to the true randomness of the qubit sequence. This SoC-based system was used in real scenarios for demonstration of urban QKD networks as well in several QKD/QRNG experiments realized by the QuantumFuture research group. Recently, it was also integrated into the QKD systems provided by ThinkQuantum, a spin-off company from University of Padova.

Abstract category

Presenter: Dr STANCO, Andrea (Università di Padova)

Contribution ID: **53** Type: **Talk**

TBA

Thursday, 4 May 2023 14:00 (1 hour)

Abstract category

Presenter: Prof. CALARCO, Tommaso (Forschungszentrum Jülich GmbH, Universität zu Köln)

Contribution ID: **54** Type: **Talk**

TBA

Friday, 5 May 2023 09:00 (1 hour)

Abstract category

Presenter: Prof. PICHLER, Hannes

Contribution ID: **55** Type: **Talk**

Quantum simulation of SU(2) 1D dynamics with ions qudits

Friday, 5 May 2023 10:00 (30 minutes)

Gauge theories are an ubiquitous concept in physics appearing in different fields of research spanning from high energies to condensed matter. Their resolution using Monte Carlo techniques has been very successful over the years but is unable to tackle many important physical regimes occurring at finite density, especially for nonabelian theories such as quantum chromodynamics. Their alternative Hamiltonian formulation on a lattice has opened new possibilities to tackle these problems via quantum simulations. Along these lines, many proposals have been suggested but experimentally only abelian theories have been simulated so far. In this talk, we present a convenient formulation of a 1D SU(2) nonabelian model which is naturally suitable for implementation on six levels ions qudit recently developed in the lab. By choosing a convenient encoding and performing simultaneous Molmer-Sorensen gates we show that a quite shallow circuit is needed to perform a quantum digital simulation of the model.

Abstract category

Presenter: Dr CALAJÒ, Giuseppe

Contribution ID: **58** Type: **Talk**

Quantum light-matter interaction with a dielectric sphere: theory and applications

Friday, 5 May 2023 11:30 (30 minutes)

A major driving force of the field of levitodynamics —the levitation and control of microobjects in vacuum —is the possibility of generating macroscopic quantum states of the center-of-mass motion of a levitated nanoparticle. Not only can these states help address questions about the interplay between gravity of quantum physics or the nature of wavefunction collapse, but their mere existence would prove the validity of quantum mechanics at regimes of mass 4 orders of magnitude higher than the current record. Recent demonstrations of ground-state motional cooling and quantum control along one motional direction (1D) show that such quantum regime of levitated nanoparticles is within experimental reach. Still, the generation and certification of macroscopic quantum states requires to answer crucial fundamental questions, for instance: can one break the seemingly fundamental limitation which allows to only feedback-cool efficiently one of the three motional degrees of freedom? How to protect motional quantum states from decoherence? and how to generate the strong nonlinearity needed to observe purely quantum (Wigner-negative) states?

In my talk, I will discuss our team's theoretical effort to answer these questions. I will introduce our recently developed theoretical formalism describing the quantum interaction between light and a trapped dielectric sphere of arbitrary size. I will show how we quantitatively predict that (i) 3D ground-state feedback cooling is possible for particles beyond the point-dipole approximation (ii) laser-induced motional decoherence can be fully suppressed by using squeezed light and (iii) shifting from harmonic to double-well potentials allows to generate detectable Wigner negativities within the motional coherence lifetime. Our work sets the theoretical basis of 3D levitated optomechanics and provides the tools to design future macroscopic quantum physics experiments.

Abstract category

Presenter: GONZALEZ-BALLESTERO, Carlos (Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria)

Contribution ID: **62** Type: **Poster**

Supervised learning of random quantum circuits via scalable neural networks

Classical simulations of quantum algorithms play a pivotal role in the development of quantum computing devices. They are essential both for providing benchmark data for validation and for representing a crucial term of comparison to justify claims of quantum speed-up in the solution of computational problems.

In this study, we investigate the supervised learning of output expectation values of random quantum circuits [1]. Deep convolutional neural networks (CNNs) are trained to predict single-qubit and two-qubit expectation values using databases of classically simulated circuits. These circuits are built using either a universal gate set or a continuous set of rotations plus an entangling gate, and they are represented via properly designed encodings of these gates.

We analyze the prediction accuracy for previously unseen circuits, comparing the performance of our CNNs with small-scale quantum computers available from the free IBM Quantum program. The CNNs often outperform these quantum devices, depending on the circuit depth, on the network depth, and on the training set size.

Notably, our CNNs are designed to be scalable, allowing us to exploit transfer learning and perform extrapolations to circuits larger than those included in the training set. Moreover,these CNNs demonstrate remarkable resilience against noise, remaining accurate even when trained on (simulated) expectation values averaged over very few measurements.

[1] Simone Cantori et al 2023 Quantum Sci. Technol. 8 025022

Abstract category

Quantum Computing

Primary authors: VITALI, David (Università di Camerino); PILATI, Sebastiano; CANTORI, Simone (Università di Camerino)

Presenter: CANTORI, Simone (Università di Camerino)

Contribution ID: **63** Type: **Poster**

Accelerating projective quantum Monte Carlo simulations using data from quantum annealers

Adiabatic quantum computers, such as the quantum annealers developed by D-Wave Systems Inc., have gained significant attention in recent years due to their potential for quantum computation. They are also increasingly being used in hybrid classical-quantum approaches to solve complex problems.
For instance, autoregressive neural networks have been employed to accelerate Monte Carlo simulations of classical spin glasses through autoregressive neural networks [1].
Here, we investigate the potential of adiabatic quantum computers in enhancing projective quantum Monte Carlo (PQMC) algorithms for determining the ground-state of quantum spin models. We utilize low-energy spin configurations generated by a D-Wave quantum annealer to train neural quantum states represented as restricted Boltzmann machines. These models are then utilized as guiding wave functions in PQMC simulations.
We evaluate the efficiency of our approach in terms of equilibration time and suppression of systematic biases for ferromagnetic and random quantum Ising models. Our preliminary results demonstrate the potential for improved efficiency in these simulations.

[1] G Scriva, E Costa, B McNaughton, S Pilati, Accelerating equilibrium spin-glass simulations using quantum annealers via generative deep learning, arXiv:2210.11288 (2022)

Abstract category

Numerical Methods

Primary authors: BRODOLONI, Luca (University of Camerino); Mr SCRIVA, Giuseppe (University of Camerino); Prof. PILATI, Sebastiano (University of Camerino)

Presenter: BRODOLONI, Luca (University of Camerino)

Contribution ID: **64** Type: **Poster.**

Quantum Magic via Perfect Sampling of Matrix Product States

We introduce a novel breakthrough approach to evaluate the nonstabilizerness of an N-qubits Matrix Product State (MPS) with bond dimension χ. In particular, we consider the recently introduced Stabilizer Rényi Entropies (SREs). We show that the exponentially hard evaluation of the SREs can be achieved by means of a simple perfect sampling of the many-body wave function over the Pauli string configurations. The MPS representation enables such a sampling in an efficient way with a computational cost O(Nχ^3), no matter the Rényi index $n > 0$. The accuracy, being size-independent, can be arbitrarily improved with the number of samples. We benchmark our method over randomly generated magic states, as well as in the ground-state of the quantum Ising chain. Exploiting the extremely favourable scaling, we easily have access to the non-equilibrium dynamics of the SREs after a quantum quench.

Abstract category

Numerical Methods

Primary author: LAMI, Guglielmo (SISSA)

Co-author: Prof. COLLURA, Mario (SISSA)

Presenter: LAMI, Guglielmo (SISSA)

Contribution ID: **65** Type: **Talk**

Controlling topological phases of matter with quantum light

Tuesday, 2 May 2023 11:30 (30 minutes)

Controlling the topological properties of quantum matter is a major goal of condensed matter physics. A major effort in this direction has been devoted to using classical light in the form of Floquet drives to manipulate and induce states with non-trivial topology. A different route can be achieved with cavity photons. In this talk, I will discuss a prototypical model for topological phase transition, the one-dimensional Su-Schrieffer-Heeger (SSH) model, coupled to a single mode cavity. I will demonstrate that quantum light can affect the topological properties of the system, including the finite-length energy spectrum hosting edge modes and the topological phase diagram. In particular, I will show that depending on the lattice geometry and the strength of light-matter coupling one can either turn a trivial phase into a topological one or vice versa using quantum cavity fields. Furthermore, the polariton spectrum of the coupled electron-photon system contains signatures of the topological phase transition in the SSH model.

Abstract category

Other

Primary author: DMYTRUK, Olesia (CNRS, Ecole Polytechnique)

Presenter: DMYTRUK, Olesia (CNRS, Ecole Polytechnique)

Contribution ID: **66** Type: **Poster.**

Cluster extensions of Dynamical Mean-Field Theory and interacting topology

In the context of strongly correlated electron systems, Dynamical Mean-Field theory has provided a powerful solution framework capable of addressing all the relevant energy scales of the system and describing features, such as the Mott transition, that escape standard Mean-Field treatment. It is however by construction completely local, hence not entirely adequate to address inherently momentum-dependent phenomena such as interacting topological phases. Here I will discuss two different and somewhat complementary real-space cluster extensions of DMFT, Cluster-DMFT and Variational Cluster Approximation, in their Exact Diagonalization implementation. I will then provide examples of the additional information they provide for topological features both in the Fermi liquid and Mott insulator phases.

Abstract category

Numerical Methods

Primary author: CRIPPA, Lorenzo

Presenter: CRIPPA, Lorenzo

Contribution ID: **67** Type: **Poster.**

ROTOGP: a classical optimizer for Variational Quantum Simulation using Gaussian Process Models

Variational Quantum Simulation (VQS) is one of the most promising techniques for near-term quantum computing. However, its performance is strongly affected by the ability of classical optimizers to deal with noise. In this context, I will first introduce Gaussian Process Models (GPM), a well-established machine learning technique to fit functionals with error bars, and then show how they can be applied to VQS. Furthermore, I will present ROTOGP, a novel optimizer exploiting GPM and a simple strategy to increase the number of measurement shots during the optimization. I will show results on some ground state preparation benchmark problems, using different circuit ansaetze, and compare with other competitive optimizers in the literature.

Abstract category

Quantum Computing

Primary author: Dr ARCECI, Luca (Innsbruck University)

Co-authors: Dr VAN BIJNEN, Rick (Innsbruck University); Dr KUZMIN, Viacheslav (Innsbruck University)

Presenter: Dr ARCECI, Luca (Innsbruck University)

Contribution ID: **68** Type: **Poster.**

Implementing a Z2 Lattice Gauge Theory on a Digital Quantum Simulator

Digital quantum simulators provide a table-top platform for addressing salient questions in particle, nuclear, and condensed-matter physics. A particularly rewarding target is given by lattice gauge theories (LGTs). Their constituents, e.g., charged matter and the electric gauge field, are governed by local gauge constraints, which are highly challenging to engineer and which lead to intriguing yet not fully understood features.
In recent work [1], we simulate a 1+1d Z2 LGT on a superconducting quantum chip. Our experiments have been performed remotely within the Early Access Program of Google Quantum AI. Efficiently synthesizing the three-body charge–gauge-field interaction renders single Trotter steps only 8 native two-qubit gates deep, enabling us to reach simulation times of up to 25 Trotter steps. We observe how tuning a term that couples only to the electric field confines the charges, a manifestation of the tight bond that the local gauge constraint generates between both. Moreover, in previous work [2], we outlined a procedure to protect gauge invariance against coherent errors by the addition of terms linear in the theory's generators. We make use of this in the experiment to study a different mechanism, where a modification of the gauge constraint from a Z2 to a U(1) symmetry freezes the system dynamics. To address and mitigate hardware errors, we, i.a., employ Floquet calibration, spin echo sequences, qubit and coupler selection, and qubit assignment averaging.
Our work showcases the dramatic restriction that the underlying gauge constraint imposes on the dynamics of an LGT, it illustrates how gauge constraints can be modified and protected, and it promotes the study of other models governed by many-body interactions.

[1] JM, W. Mruczkiewicz, J.C. Halimeh, Z. Jiang, P. Hauke, arXiv:2203.08905 [quant-ph], March 2022

[2] J.C. Halimeh, H. Lang, JM, Z. Jiang, P. Hauke, PRX Quantum 2, 040311, October 2021

Abstract category

Quantum Computing

Primary authors: MILDENBERGER, Julius; MRUCZKIEWICZ, Wojciech; HALIMEH, Jad; JIANG, Zhang; Prof. HAUKE, Philipp

Presenter: MILDENBERGER, Julius

Contribution ID: **69** Type: **Poster.**

On the indistinguishability of photon-pair sources: resonant or not resonant, that is the question

We demonstrate and compare the on-chip Hong-Ou-Mandel interference between two micro-ring resonators and two straight waveguides used as indistinguishable twin photons sources for quantum photonic applications.

Abstract category

Photonics

Primary author: SANNA, Matteo (University of Trento)

Co-authors: Mr LEE, Jong-Moo (ETRI (South Korea)); Dr BALDAZZI, Alessio (University of Trento); Prof. AZZINI, Stefano (University of Trento); Dr AHN, Joon Tae (ETRI (South Korea)); Dr LEE, Myung Lae (ETRI (South Korea)); Dr SOHN, Young-Ik (KAIST(south korea)); Prof. PAVESI, Lorenzo (University of Trento)

Presenter: SANNA, Matteo (University of Trento)

Contribution ID: **70** Type: **Poster**

Quantum Computing applications of the Hubbard-Stratonovich transformation

Studies about the possible exploitation of the Hubbard-Stratonovich transformation to the implementation of multi-qubit quantum gates in circuit-based quantum processors.

Abstract category

Quantum Computing

Primary author: VESPUCCI, Luca (ECT*)

Presenter: VESPUCCI, Luca (ECT*)

Contribution ID: **71** Type: **Poster**

Entanglement witnessing for lattice gauge theories

LGTs are at the core of fundamental physics and, recently, substantial theoretical and experimental efforts have gone into simulating LGTs using quantum technologies.
In the quantum realm, entanglement plays a crucial role and its detection can be efficiently performed using entanglement witnesses.
Yet, entanglement witnessing in LGTs is extremely challenging due to the gauge constraints, that severely limit the operators that can be employed to detect quantum correlations.
In this work, we develop the theoretical framework of entanglement witnessing in lattice gauge theories and, by way of illustration, consider bipartite entanglement witnesses in a U(1) LGT (with and without fermionic matter).
Our framework, which avoids the costly measurements required, e.g., by full-tomography, opens the way to future theoretical and experimental studies of entanglement in an important class of many-body models.

Abstract category

Other

Primary authors: Prof. HAUKE, Philipp H. J. (Università degli Studi di Trento, INO-CNR Pitaevskii BEC, TIFPA-INFN); Dr COSTA DE ALMEIDA, Ricardo (Università degli Studi di Trento, INO-CNR Pitaevskii BEC, University of Heidelberg, INFN-TIFPA); PANIZZA, Veronica (Università degli Studi di Trento, INO-CNR Pitaevskii BEC, TIFPA-INFN)

Presenter: PANIZZA, Veronica (Università degli Studi di Trento, INO-CNR Pitaevskii BEC, TIFPA-INFN)

Contribution ID: **72** Type: **Talk**

Non-abelian Berry's phase in photonic waveguides arrays

Wednesday, 3 May 2023 14:00 (1 hour)

Non-abelian gauge fields emerge naturally in the description of adiabatically evolving quantum systems. In this talk we show that they also play a role in Thouless pumping in the presence of degenerate bands. Specifically, we consider a photonic Lieb lattice and show that when the lattice parameters are slowly modulated, the propagation of the photons bears the fingerprints of the underlying non-abelian gauge structure.
The non-dispersive character of the bands enables a high degree of control on photon propagation. Our work paves the way to the generation and detection of non-abelian gauge fields in photonic and optical lattices. The talk includes a review of the physics photonic waveguide arrays as quantum simulators and perspectives on quantum applications of Thouless pumps.

Abstract category

Presenter: Dr BROSCO, Valentina (CNR, ISC, Università 'La Sapienza' di Roma)

Contribution ID: **73** Type: **Talk**

On-chip genuine three-qubit entanglement from a deterministic source

Thursday, 4 May 2023 11:30 (30 minutes)

Multi-photon entangled state is the key ingredient in realizing measurement-based quantum computing. The current proposals for universal quantum computation require simultaneously high generation rates, high fidelity, and low loss, which are beyond the capability of the current experimental systems. In this work, we address this critical problem by demonstrating the on-chip deterministic generation of a three-qubit state. Our work bridges the gap toward an ideal platform where photons are collected with almost unity efficiency on-chip. Using a quantum dot embedded in a photonic crystal waveguide, we charge it deterministically with a single electron spin. We control the electron spin environment by narrowing the nearby nuclear spin distribution, thus improving the $T2^*$ time by a factor of 10. Moreover, we demonstrate genuine three-qubit entanglement, which consists of an electron spin and two indistinguishable photons. Our work constitutes a key step toward the next-generation device where the criteria for a fully-fledged photonic quantum computer can be fulfilled.

Presenter: MENG, Yijian (Niels Bohr Institute, University of Copenhagen)

Contribution ID: **74** Type: **Talk**

Emergent Pauli blocking in a one-dimensional Bose gas

Friday, 5 May 2023 14:30 (30 minutes)

The relationship between many-body interactions and dimensionality is key to emergent quantum phenomena. A striking example is the Bose gas, which upon confinement to one dimension (1D) obeys an infinite set of conservation laws, prohibiting thermalization and steering dynamics. We experimentally demonstrate that the integrable dynamics of a Bose gas can persist deep within the dimensional crossover regime. Starting from a weakly interacting, one-dimensional Bose gas, we perform a quench to instigate dynamics of a single density mode. We find that its relaxation accurately follows predictions of dephasing from the integrable theory, even for temperatures up to three times the conventional limit for one-dimensionality. We attribute our observations to an emergent Pauli blocking of the 3D excitations, caused by the relevant collective excitations of the system assuming fermionic statistics, despite the gas being comprised of weakly interacting bosons. Our experiment demonstrates how the integrable solutions can be employed to establish a direct link between microscopic details of the system and its observed macroscopic behaviour, thus presenting new avenues to investigate emergent quantum many-body phenomena.

Presenter: Dr CATALDINI, Federica (TU Wien)

Contribution ID: **75** Type: **Poster**

Numerical approaches for non-adiabatic terms in quantum annealing

Adiabaticity can be used to improve accuracy and precision of many quantum control procedures such as quantum annealing, adiabatic quantum computing and ground state preparation. However, processes need to be implemented very slowly to achieve the adiabatic limit, lengthening control sequences and increasing the susceptibility of the system to decoherence. One approach to overcoming this problem is to apply counterdiabatic driving, which can be defined via a quantity known as the Adiabatic Gauge Potential (AGP). The AGP characterises the adiabaticity of a system, and in general is a difficult quantity to compute. We present a new approach to symbolically computing the AGP using commutation relations, which we apply to the Ising graph Hamiltonian class as an example. This new approach allows efficient computation of the AGP on larger graphs than were previously possible with other methods.

Abstract category

Numerical Methods

Primary author: LAWRENCE, Ewen (University of Strathclyde)

Co-authors: Mr SCHMID, Sebastian; Ms CEPAITE, Ieva (University of Strathclyde); Dr KIRTON, Peter (University of Strathclyde); Dr DUNCAN, Callum (University of Strathclyde)

Presenter: LAWRENCE, Ewen (University of Strathclyde)

Contribution ID: **78** Type: **Poster**

First-order photon condensation in magnetic cavities: A two-leg ladder model

Recently, the existence of Dicke-like equilibrium superradiant phase transitions in cavity QED many-body system has been put into question —resulting in no-go theorems on spontaneous photon condensation. Specifically, the no-go theorems tells us that the superradiant phase transition is prohibited as long as a single-mode purely electrical vector potential is considered, with the transition being analogous to a magnetostatic instability. In this work [1] we consider a minimal setting beyond 1D –i.e., a two-leg ladder –where the orbital motion of spinless fermions is coupled through Peierls substitution to a non-uniform cavity mode which generates a fluctuating magnetic field. Thanks to the quasi-one dimensional geometry we are able to scrutinize the accuracy of (mean field) cavity-matter decoupling against large scale density-matrix renormalization group simulations and study light-matter entanglement properties as well as the exact cavity state. Our results show that ladder geometries can indeed photon condensation and in particular they serve as a first simple example of first-order photon condensation in a gauge-invariant scenario; highlighting how, in the quest for photon condensed phases, looking for only second order instabilities might be limiting.

[1] arXiv:2302.09901v2

Abstract category

Quantum Optics

Primary author: BACCICONI, Zeno (SISSA - Scuola Internazionale di Studi Superiori)

Co-authors: ANDOLINA, Gian Marcello (College de France, Paris.); Mr CHIRIACÒ, Giuliano (ICTP, Trieste); Mr DALMONTE, Marcello (ICTP, Trieste); Mr SCHIRÒ, Marco (College de France, Paris); Mr CHANDA, Titas (ICTP, Trieste)

Presenter: BACCICONI, Zeno (SISSA - Scuola Internazionale di Studi Superiori)