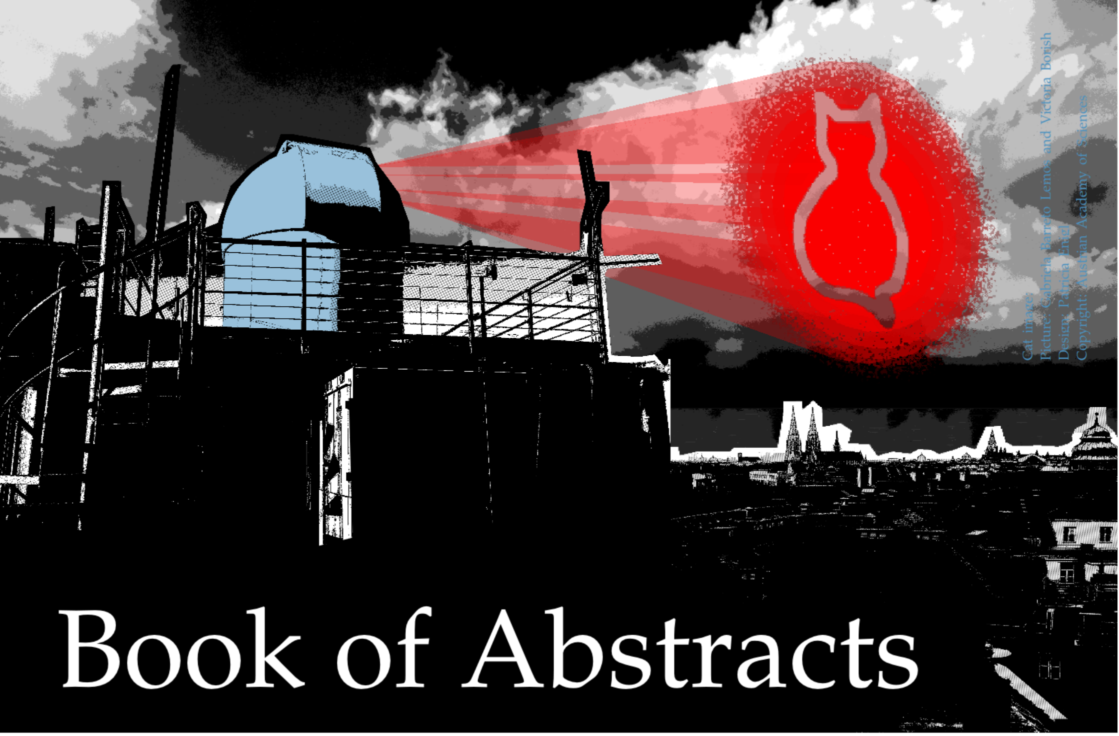

Book of Abstracts

Contributed Posters

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Contents

Poster Session

Monday 18th September

Optimal estimation of parameters encoded in coherent states quadratures

Matthieu Arnhem

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Poster no. 1

We consider the problem of encoding and estimating multiple classical parameters in conjugate variables such as the quadratures of the coherent states of light. We derive the Quantum Cramér-Rao bounds (QCRB) for an arbitrary linear encoding of two classical parameters into the quadratures of two coherent states. Furthermore, we present an encoding and estimation protocol which achieve the QCRB for both classical parameters estimated simultaneously. Finally, we generalize our protocol to encode a set of N classical parameters into a set N of coherent states such that one can always simultaneously estimate these parameters optimally using a measurement technique involving only beam-splitters and phase-shifters. A corollary of our work is the proof of optimality of the measurement scheme proposed by N. J. Cerf and S. Iblisdir in 2001, which was left as an open problem.

Compact on-chip-conversion of microwave and optical signals using nanomechanical transducers

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Poster no. 2

Superconducting circuits are promising candidates for future quantum processors. However, when it comes to long distance communication, small energy microwave qubits show significant drawbacks compared to optical photons, since optical fibers offer ultra-low loss transmission and unmatched resilience to thermal noise and environmental interference. Efficient conversion between microwaves and optical wavelengths would therefore represent a key feature to establish a long distance quantum network of superconducting processors. Our work aims at the development of an integrated on-chip transducer that couples microwaves to optical photons with efficiencies exceeding 50%. Our approach bases on a transducer that combines optomechanical photonic crystal cavities and capacitive-electromechanical modulation on an SOI platform fully compatible with superconducting qubits. We will present our progress in design, fabrication, and first experiments on transducers that couple superconducting circuits on chip to optomechanical cavities. Such platforms may find application not only in quantum communication but also for ultra-sensitive RF detection.

Dynamics of quantum heat engines: A comprehensive analysis

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Poster no. 3

We study a quantum heat engine with arbitrary coupling strength to its environment. This engine is a simplified version of the Carnot engine, consisting of two thermalization strokes and two adiabatic strokes in each cycle. Employing solvable models, optomechanical interaction as adiabatic process and collision Hamiltonian for thermalization, makes it possible to calculate the exchanged energy of the system exactly. Considering correlations and their effects on energy exchanges, we give a detailed description of the engine performance. Though the efficiency of the engine is affected by the coupling strength, we cannot claim that it passes the Carnot bound. on the other side our results proves that the efficiency depends on parameters rather that the temperatures of the baths. The interaction strength may even make the cycle to switches between an engine and a refrigerator. The performance of the refrigerator is also investigated under the influence of coupling strength variation. At a glance, we shall say in quantum cases, we should trace the expense of increasing the coupling.

Non-contextuality N-Cycle inequalities in a Scenario of Multiple Observers

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Poster no. 4

To investigate contextuality in a classical limit, we analyze a scenario (inspired in Quantum Darwinism) in which N-cycle non-contextuality inequalities are sequentially tested by many observers on the same quantum central system of dimension 3. All observers are independent and cannot communicate with each other. There are two variations for this scenario: a) each observer makes a complete measurement or b) each observer measures the dichotomical observable of the inequality, preserving coherence in a subspace of dimension 2. We then study the sum of expected values that led to violation of the inequality in the usual scenario, showing limits for which contextuality cannot be witnessed anymore (in the sense that the inequalities are not violated). We interpret the first version in terms of a classical Markovian process, discuss the meaning of the assymptotic limit of infinite observers for each (odd) N and relations of this scenario to contextuality in open quantum systems and classical limits of quantum theory.

Nonlocality with sequential measurements beyond local pre-processing

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Poster no. 5

We consider nonlocality tests (Bell nonlocality and Einstein-Podolsky-Rosen-steering) in a scenario where the parties can perform a sequence of time-ordered measurements. When two rounds of measurements per party are considered and the first round has a fixed one, this scenario can be understood as local pre-processing where the first round admits the interpretation of a local filter. In previous works, this pre-processing has shown to be useful to reveal the so-called “Hidden nonlocality” of quantum states that never displayed Bell nonlocality in standard Bell tests. Here we go beyond simple pre-processing by exploring general sequential measurements that do not admit a local filtering interpretation and present a method to investigate this scheme in context of Einstein-Podolsky-Rosen-steering. We show that analysing statistical data under a general time order assumption is useful to certify entanglement and can provide an advantage over local pre-processing to reveal Einstein-Podolsky-Rosen-steering and other nonclassical properties of measurement statistics.

N00N-like Multiphoton Interferences from Two Thermal Light Sources

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Poster no. 6

N00N-states have been introduced originally to produce superresolving interference patterns by use of collective N-photon states propagating along two possible quantum paths [Boto, et al., PRL, 85, 2733 (2000)]. Recent experiments have shown that K independent, incoherently emitting thermal light sources (TLS) can generate similar superresolving multiphoton interferences when measuring the mth-order intensity correlation function for $m = K$ and if $m-1$ detectors are placed at particular positions [Oppel, et al., PRL, 109, 233603 (2012)]. Employing the same $m-1$ fixed detector positions we reveal that N00N-like interferences of arbitrary order can be generated with merely two independent TLS, when measuring higher-order intensity correlation functions of order $2(m-1)$ with additionally $m-1$ moving detectors. We show that the resulting interference patterns can be interpreted as N00N-like Hanbury Brown and Twiss interferences with $N = m - 1$. We then discuss a slightly modified setup to reach a higher contrast and present first measurements to confirm our theory.

Generation of Double Twin Beams of atoms

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Poster no. 7

A Bose-Einstein condensate is a special state of matter where bosonic atoms are brought close together to occupy the same quantum state, similarly to a laser in optics. Interactions within atoms can act as a parametric down conversion process and lead to the generation of quantum correlated atom pairs which show reduced fluctuations in the number difference (twin-atom states). Here we use a double well confinement for the atoms in a cigar-shaped BEC to add a transversal separation (left or right well) to the emitted twin beams (Double Twin Beams).

The ground of quantum communication advantage

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Poster no. 8

Where does quantum advantage spring from? Such an investigation necessitates invoking an ontology on which non-classical features of quantum theory are explored. One such non-classical ontic-feature is preparation contextuality (PC) and advantage in oblivious communication tasks is its operational signature. This letter primarily addresses quantum advantage in communication complexity (CC). We demonstrate that quantum advantage in CC operationally reveals PC. Specifically, we construct oblivious communication tasks tailored to given CC problems. The bound on classical success probability in the oblivious communication tasks forms our preparation non-contextual inequalities. We use the same states along with their orthogonal mixtures and the same measurements responsible for advantage in CC problems to orchestrate an advantageous protocol for the oblivious communication tasks and the violation of the associated inequalities. Further, we find a criterion for unbounded violation of these inequalities and demonstrate the same for two widely studied CC problems. Additionally, the tools thus developed enables the complete proof of the fact that (spatial and temporal) Bell-inequality violation implies an advantage in oblivious communication tasks, thereby revealing PC. Along with the implications of this work, we discuss other known indications towards our assertion that PC is the principal non-classical feature underlying quantum advantage.

The computation behind the physical scenes

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Poster no. 9

Algorithmic information theory (AIT) is the field centered around Kolmogorov complexity. It offers a powerful formalization of the complementary notions of randomness and compressibility. While standard Shannon entropy quantifies the randomness in a process (what could be), algorithmic entropy quantifies the randomness of specific instances of information (what is). Interesting applications of AIT include analyzing in this non-counterfactual way non-local computations (namely PR boxes) and noisy communication (e.g. the erasure channel). In the other direction, one can upper bound the lossless compressibility of information through AIT. One can thus assign work value to strings of information by revisiting Landauer's principle, which quantifies the energy needed for irreversible computations (e.g. erasures). Can the quantum variant of AIT add something more? This poster gives a general overview of the field through some results and open problems and aims at stimulating discussion around these topics.

New Bell inequalities for three qubit states and extension to facet scenario

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Poster no. 10

We introduce a set of Bell inequalities for a three-qubit system. Specialty of this set is that each inequality within the set is violated by all generalized GHZ states, which are problematic with most of the well known Bell inequalities in the sense that those inequalities are not violated by all generalized GHZ states. Also, our set of inequalities establishes a relation between nonlocality and entanglement for this class of states as we have showed that more entangled a generalized GHZ state is, more will be the violation. Certain inequalities within this set are violated by pure biseparable states, making us able to distinguish between separable, biseparable and genuinely entangled pure three-qubit states. We also provide numerical evidence that at least one of these Bell inequalities is violated by a pure genuinely entangled state. We generalize this set to n-qubit systems and that may be suitable to characterize the entanglement of n-qubit pure states. This work introduces a special scenario where out of the three parties one party make only one dichotomic measurement instead of two. Following this work we have constructed the facets of the local polytope for the scenario of three parties, two dichotomic measurement settings for two parties and one dichotomic measurement for the remaining and got only one nontrivial facet up to relabeling of indices. We then showed that the propositions from the previous paper remain valid for the new facet inequality also. We next analyzed the inequality for some noisy mixed states.

Completely Positive Maps for Reduced States of Indistinguishable Particles

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Poster no. 11

We discuss a framework for the construction of completely positive maps for subsystems of indistinguishable fermionic particles. In this scenario, the initial global state is always correlated, and it is not possible to tell system and environment apart. Nonetheless, a map in the operator sum representation is possible if the particles have only exchange correlation. To classify the correlations, we introduce a multipartite mutual information for indistinguishable particles.

Cavity and circuit QED in the non-perturbative regime

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Poster no. 12

We study a generic cavity-QED system where a set of (artificial) two-level dipoles is coupled to the electric field of a single-mode LC resonator. This setup is used to derive a minimal quantum mechanical model for cavity QED, which accounts for both dipole-field and direct dipole-dipole interactions. The model is applicable for arbitrary coupling strengths and allows us to extend the usual Dicke model into the non-perturbative regime, which can be associated with an effective finestructure constant of order unity. In this regime we identify and characterize three distinct classes of normal, superradiant and subradiant vacuum states and study the transitions between them. Our findings reconcile many of the previous, often contradictory predictions on this topic and provide a unified theoretical framework to describe ultrastrong coupling phenomena in a large variety of physically very different cavity-QED platforms.

Quantifying measurement incompatibility of mutually unbiased bases

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Poster no. 13

Quantum measurements based on mutually unbiased bases are commonly used in quantum information processing, as they are generally viewed as being maximally incompatible and complementary. We quantify precisely the degree of incompatibility of mutually unbiased bases (MUB) using the notion of noise robustness. Specifically, for sets of k MUB in dimension d, we provide upper and lower bounds on this quantity. Notably, we get a tight bound in several cases, in particular for complete sets of $k = d + 1$ MUB (given d is a prime power). Moreover, we prove the existence of sets of k MUB that are operationally inequivalent, as they feature different noise robustness. Finally, we discuss applications of our results for Einstein-Podolsky-Rosen steering.

Experimental resource-efficient entanglement detection

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Poster no. 14

The conventional entanglement detection schemes assume an idealized situation where an infinite number of copies of a quantum system is available. Therefore, repeated measurements can be performed in order to extract the mean values of desired quantities, such as entanglement witnesses. In practice, the procedure boils down to collecting "sufficiently large" statistics from a large ensemble of equally prepared copies of the entangled state. However, due to various technical and fundamental challenges, many practical situations involve only a limited number of instances of a given quantum resource, especially when dealing with large-scale entangled quantum systems. In such a situation, the standard detection methods are questionable because of insufficient experimental data and consequently large experimental errors. Therefore, our aim is to develop a scheme for the probabilistic verification of quantum resources. The main idea is to merge the method of random sampling and quantum information processing together, to design a practically feasible framework. Random sampling is an important technique in statistical analysis which consists of selecting of a small part of population in order to learn certain global properties at low cost. From our point of view, the verification method should not rely on criteria that implicitly assumes an ideal situation of an infinite number of repetitions. For example, rather than saying: "The state is entangled if $\langle W \rangle > 1/2$", we should ask: "What is the probability that the measurement (of W) returns the outcome satisfying $\langle W \rangle > 1/2$?"Thus, rather then focusing on a large ensemble of independent and identically distributed copies of a quantum resource in question, we want to perform a single experimental run and use the probability of success for the quantum system to perform certain information tasks as the central quantity for verification of the presence/absence of the quantum resource (e.g. the state was entangled/separable). We show that for a variety of large quantum states even a single copy suffices to detect entanglement with a high probability by using local measurements. For example, a single copy of a 16-qubit k-producible state or one copy of 24-qubit linear cluster state suffices to verify entanglement with more than 95% confidence. Our method is applicable to many important classes of states, such as cluster states or ground states of local Hamiltonians in general. Moreover, we go further showing that this method can be used to translate any entanglement witness to this probabilistic framework. In this way, entanglement detection can be easily carried out in a resource-efficient way, meaning that only a reduced number of copies of a quantum system leads to reliable entanglement verification. To benchmark our theoretical findings, we report the experimental entanglement verification in a photonic six-qubit cluster state generated using three photon-pair sources at telecom wavelength. We find that entanglement can be certified with at least 99.74% confidence by using only around 20 copies of the state. This novel method entails a significant reduction of resources and provides an easy tool to certify the presence of entanglement in large-scale systems, promising a great impact in future experiments where an efficient and resource-saving approach will be essential for entanglement verification problems in multi-qubit states.

On the dynamics of some nonlocality-related properties

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Poster no. 15

It is well known that Bell-nonlocality and its generalisations (through the activation of nonlocality scenarios) are properties stronger than entanglement, in the sense that they first require of it in order to emerge. It is also well known that quantum systems in interaction with an environment may display entanglement dynamics such as death-revival (EDR) and sudden birth (ESB). In this work, we explore the dynamics of some nonlocality-related properties in a two-qubit system in interaction with an environment, when it undergoes different entanglement dynamics.

The Ou-Mandel experiment revisited: producing delocalized Schrödinger cats by local frequency-time filtering

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Poster no. 16

In the OM experiment, spatial beating was observed in a photon coincidence measurement which comes from the interference of two paths containing two frequency filters at different centered frequencies. We propose a new interpretation of the fringe pattern observed in this experiment: a frequency-time cat state is post-selected out of the state produced by a SPDC source, and this structure can be revealed using the generalization of the HOM experiment proposed in [Boucher et al., Phys. Rev. A 92, 023804, (2013)] . Hence, we present a new way of engineering and detecting time-frequency entanglement by post-selection using frequency-time filtering. Finally, we propose a tomography for the postselected state thanks to this scheme.

Quantum batteries

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Poster no. 17

Quantum batteries are physical systems able to exchange the energy and entropy with their surroundings, to store it in some appropriate form and finally release the energy and entropy to the surroundings again. Our interest is focused on the idea of charging a quantum battery, represented by qubits with non-zero energy gaps. First, we apply beam-splitters to our independent qubits in order to bind them into one system. It doesn't affect average energy of the qubits, but does create a coherence. Further, we make a projective measurement, which lets us condition on the outcome, particularly, keep the certain one. Our goal is to increase probabilistically the energy of our battery and its coherence (relative entropy) at the same time. Moreover, the more input qubits we use, the more energy we should gain. Mixing lower energy states of qubits by beam-splitter with further post selection of the state of the system, when the majority of qubits are in the excited states, fits our purposes. This method is tested for different quantum states: thermal states, pure quantum states and amplitude-damping states.

Separability Criterion for Quantum Effects

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Poster no. 18

Entanglement of an observable is a specific property of a nonlocal observable. In this talk, I will talk about a binary observable (a quantum effect). I consider the situation where Alice and Bob prepare states respectively and they perform a nonlocal binary measurement. The research question is whether this measurement is entangled or not. For a binary observable, the dual version of the Bell-Clauser-Horne-Shimony-Holt (Bell-CHSH) inequality is proposed as a separability criterion. The violation of the inequality implies that the given binary observable is entangled. This violation is experimentally checked by using a cloud quantum computer, called IBM Quantum Experience. I also discuss an application of the entanglement of observables to quantum teleportation.

The Hawking effect in dispersive media

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Poster no. 19

The Hawking effect of spontaneous emission at the horizon of black holes is one of the outstanding predictions of quantum field theory. However, because of its ultra-low temperature, observing it in the astrophysical context is an inconceivable feat. Fortunately, it is possible to create event horizons for waves in media, which renders the observation of this quantum emission doable. If the initial proof of this analogy between wave motion on curved spacetimes and the kinematics of waves in media was derived without accounting for the effect of dispersion, it has since been realised that the influence of the latter is actually key to enabling the experimental creation of analogue horizons. Here, we show in which regimes of dispersion the Hawking effect may really be observed in an optical-analogue scheme. We consider the limits and epistemology of the analogy to the astrophysical system thus drawn. We propose an onthological shift, whereby the necessity for experiments to operate in dispersion regimes in which the analogy cannot be mathematically derived is acknowledged. This will aid bridging from the theoretical to the experimental realms.

Reversibility and its Connection to the Quantum Computational Speed-up

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Poster no. 20

For all we know, quantum computers can solve certain problems faster than any classical computer. This drives several large research programs in both academia and industry, where one of the important goals is to understand the reason for this speed-up; to understand what resources a quantum system provides that enable the computational advantage. Some candidates for such resources are superposition and interference, entanglement, non-locality, contextuality, and the continuity of the state space. Another property that distinguish quantum systems, from those used in classical information processing, is that they have additional degrees-of-freedom. Here we investigate the role of these additional degrees-of-freedom and show how the speed-up emerges from the restriction of reversibility (more precisely unitarity). Our result also has implications to post quantum cryptography, and raises the question of whether quantum parallelism rather should be viewed as a computation performed in an additional degree-of-freedom.

Tomographic reconstruction of multi-time correlations for any open quantum dynamics

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Poster no. 21

We present a new technique, which allows efficient simulation of non-Markovian quantum dynamics. The technique is a generalisation of the transfer tensor method [Cerrillo, Cao, Phys. Rev. Lett. 112, 110401, 2014], which extends the method to the efficient propagation of multi-time correlations. The generalisation is naturally expressed within the process tensor framework [Pollock et al., Phys. Rev. A 97, 012127, 2018], and can be derived operationally by emulating the structure of the Nakajima-Zwanzig projection operators. The generalised transfer tensor method allows for efficient long-time simulations with approximately constant error, and provides a well-defined way of deriving extended Nakajima-Zwanwig master equations describing multi-time correlations. An explicit application of the developed method to the spin-boson model is presented.

Dynamical fidelity susceptibility of decoherence free subspaces

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Poster no. 22

In idealized models of a quantum register and its environment, quantum information can be stored indefinitely by encoding it into a Decoherence Free Subspace (DFS). Nevertheless, perturbations to the idealized register-environment coupling will cause decoherence in any realistic setting. Expanding a measure for state preservation, the dynamical fidelity, in powers of the strength of the perturbations, we prove stability to linear order is a generic property of quantum state evolution. The effects of noise perturbations is quantified by a concise expression for the strength of the quadratic, leading order, which we define as the dynamical fidelity susceptibility of DFSs. Under the physical restriction that noise acts on the register k-locally, this susceptibility is bounded from above by a polynomial in the system size. These general results are illustrated by two physically relevant examples. Knowledge of the susceptibility can be used to increase coherence times of future quantum computers.

Mass and complexity limits of free-flight molecular interference

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Poster no. 23

Macromolecules are among the most complex systems for which coherent center-of-mass interference has been demonstrated [S. Eibenberger et al., Phys. Chem. Chem. Phys. 15, 14696-14700 (2013);P. Haslinger et al., Nat. Phys. 9, 144-148 (2013); M. Arndt et al., Nat. Phys. 10, 271-277 (2014)]. In this work, we give a constructive estimate of the mass and complexity which can be reached by optimizing the Long-baseline Universal Molecule Interferometer currently under construction in Vienna. We do this by refining the description of pattern formation and dephasing taking place in the experiment and comparing a number of standard and novel interferometer configurations.We report on the optimal schemes, discuss their fundamental limitations and the possibilities of overcoming them.

Kaleidoscope of Quantum Coherent States and Units of Quantum Information

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Poster no. 24

The Schrodinger cat states, constructed from Glauber coherent states and applied for description of qubits are generalized to the kaleidoscope of coherent states, related with regular n-polygon symmetry and the roots of unity. This quantum kaleidoscope is motivated by our method of classical hydrodynamics images in a wedge domain, described by q-calculus of analytic functions with q as a primitive root of unity. First we treat in detail the trinity states and the quartet states as descriptive for qutrit and ququat units of quantum information. Normalization formula for these states requires introduction of specific combinations of exponential functions with mod 3 and mod 4 symmetry, which are known also as generalized hyperbolic functions. We show that these states can be generated for an arbitrary n by the Quantum Fourier transform and can provide in general, qudit unit of quantum information. The average number of photons in kaleidoscope of coherent states is given by the ratio of two consecutive mod n exponential functions. Relations of our states with quantum groups, multi-qudit entangled states and quantum calculus are discussed.

Overview and Comparison of Quantum Software Platforms

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Poster no. 25

Quantum computers are available to use over the cloud, but the recent explosion of quantum software platforms can be overwhelming for those deciding on which to use. In this paper, we hope to provide a current picture of the rapidly evolving quantum computing landscape and compare four software platforms–Forest (pyQuil), QISKit, ProjectQ, and the Quantum Developer Kit–that enable researchers to use real and simulated quantum devices. Our analysis covers requirements and installation, language syntax through example programs, library support, and quantum simulator capabilities for each platform. For platforms that have quantum computer support, we compare hardware, quantum assembly languages, and quantum compilers. We conclude by covering features of each and briefly mentioning other quantum computing software packages.

Modulation of fractal structures induced by purification protocol

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Poster no. 26

Quantum entanglement is an important resource for quantum information, computation and cryptography. Therefore, some of the current research activities focus on protecting the entanglement from dissipation and detrimental environmental effects. One possible way is to use purification protocols that sacrifice a number of copies of the physical states to repair the remaining copies. Recent results indicate that such protocols can exhibit chaotic features. The main characteristics of this true quantum chaos are sensitiveness to initial input states and also fractal structure formed of these states. We briefly summarize the topic - after introducing the protocol we accentuate the chaotic properties, their physical and mathematical aspects. Then we present our main results. For the sake of simplicity we focus on single qubit quantum states. Via modification of the protocol we encounter new regimes of asymptotic evolution. Changing the parameters of the protocol these regimes spread from uniform dull evolution to white noise, i.e. each state evolves through deterministic chaotic dynamics. A good intuitive understanding of these regimes can be obtained from visual representation of the fractal structures of sensitive states. These structures can have various (noninteger) dimension values in range 0 - 3. This fact witnesses the chaotic nature of the single qubit evolution despite using only numerical approach.

Towards an experimental demonstration of Gaussian bosonic superactivation

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Poster no. 27

Experimental demonstration of phenomena unique to the quantum regime is a necessary step towards their implementation in real-world quantum technology. Our focus lies on an effect discovered in 2008 [Smith and Yard, Science]: certain zero-capacity quantum channels can "superactivate" each other, meaning that the combined quantum capacity of pairs of such channels can be strictly positive. An experimental proposal for superactivation [Smith et al., Nature Photonics, 2011] using the Gaussian quantum optical platform isn't realizable using existing technology because of its reliance on in-line squeezing. We aim to provide a feasible experiment for the Gaussian quantum optical platform. We describe a Monte Carlo search to identify optical circuits yielding superactivation. Furthermore, we address the certification of successful superactivation with experimental data: we provide quantities whose measurement is expected to give a strong claim of superactivation, even under the influence of experimental insecurities such as optical loss and noise.

Sequential Pauli Measurements: Incomplete but Complete Sets

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Poster no. 28

Destructively measuring an incomplete set of Pauli's does not allow for full state tomography. If one measures them non-destructively, and if in fact one measures sequences of Pauli's, one may get away with performing full tomography while only having access to a highly incomplete set of Pauli's. This setting naturally comes up in models of quantum computation with magic states. Here we focus on the question of deciding whether a set of Pauli's allows full tomography. This is a work in progress.

Multiplicative Bell inequalities

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Poster no. 29

We consider a two-player coordination game, similar in spirit to the CHSH game, in which Alice and Bob attempt to maximize the area of a rectangle. Alice and Bob each have two random variables, and the rectangle?s area is represented by a certain parameter, which is a function of the correlations between their random variables. We show that this parameter is a Bell parameter - i.e., the achievable bound using only classical correlations is smaller than the achievable bound using non-local quantum correlations (in the quantum case, the random variables are outcomes of quantum measurements). We continue by generalizing the parameter to the case in which Alice and Bob each have n random variables and wish to maximize a certain volume in n-dimensional space. We call this parameter a multiplicative Bell parameter and prove its Tsirelson (quantum) limit for a qubit. Finally, we investigate the case of local hidden variables and demonstrate, under specific assumptions, a reduction from the problem of finding the Bell bound to an integer programming problem. We then show that for any deterministic strategy of one of the players the Bell parameter is an n-variables harmonic function whose maximum saturates the integer programming bound for many values of n. We conjecture that this maximum can be computed efficiently, while the integer programming problem cannot be solved efficiently.

Loss of Information in Quantum Guessing Game

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Poster no. 30

Incompatibility of certain measurements is a well known property of quantum mechanics. This feature can be utilized in many contexts, ranging from Bell inequalities to device dependent QKD protocols. Typically, in these applications the measurements are chosen from a predetermined set based on a classical random variable. One can naturally ask, whether the non-determinism of the outcomes is due to intrinsic hiding property of quantum mechanics, or rather by the fact that classical, incoherent information entered the system via the choice of the measurement. Rozpedek et. al. examined this question for a specific case of two mutually unbiased measurements on systems of different dimensions. They have somewhat surprisingly shown that in case of qubits, if the measurements are chosen coherently with the use of a controlled unitary, outcomes of both measurements can be guessed deterministically. Here we extend their analysis and show that specifically for qubits, measurement result for any set of measurements with any a-priori probability distribution can be faithfully guessed by a suitable state preparation and measurement. We also show that up to a small set of specific cases, this is not possible for higher dimensions. This result manifests a deep difference in properties of qubits and higher dimensional systems and suggests that these systems might offer higher security in specific cryptographic protocols.

Tensor product algorithms for quantum control

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Poster no. 31

Quantum control is at the core of current and future quantum technologies. These systems require an ever-increasing number of components, which makes its complexity to grow exponentially. This is known as "the curse of dimensionality", and is one of the biggest challenges of modern computation. There are several algorithms that use different numerical methods to find the solutions to quantum control problems with an arbitrary degree of accuracy, but the required computational power makes them unsuitable to solve some of the most complex problems within a reasonable amount of time. Smarter numerical algorithms could greatly improve computational times if they are able to reduce the dimensionality. We proposed this could be done using tensor product formats, which exploits the internal structure of the problem. The compressibility of the states gives information about the degree of entanglement in the system, which is also a point of interest for this approach.

Quantum uncertainty relation based on the mean deviation

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Poster no. 32

Traditional forms of quantum uncertainty relations are invariably based on the standard deviation. This can be understood in the historical context of simultaneous development of quantum theory and mathematical statistics. Here, we present alternative forms of uncertainty relations, in both state dependent and state independent forms, based on the mean deviation. We illustrate the robustness of this formulation in situations where the standard deviation based uncertainty relation is inapplicable. We apply the mean deviation based uncertainty relation to detect EPR violation in a lossy scenario for a higher inefficiency threshold than that allowed by the standard deviation based approach. We demonstrate that the mean deviation based uncertainty relation can perform equally well as the standard deviation based uncertainty relation as non-linear witness for entanglement detection.

State transfer by means of discrete-time quantum walks

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Poster no. 33

We introduce the scheme of discrete-time quantum walk algorithm for the state transfer on an example of star graph. We consider the quantum walk search algorithm with two marked outer vertices, sender and receiver. We show how to simplify the problem by using square of evolution operator and by finding the invariant subspace with respect to the square of the evolution operator. We calculate the number of steps of the walk and we prove that the perfect state transfer is achieved. We briefly mention the results for other types of highly symmetric graph.

Localization of quantum walks on the Manhattan lattice and the L-lattice

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Poster no. 34

We address the problem of two-dimensional quantum walks on directed square lattices. We focus on two special cases, namely the Manhattan lattice and the L-lattice. For homogeneous quantum walks it is shown that they can be viewed as quantum walks on undirected square lattice driven by four-dimensional coin in the case of the Manhattan lattice and two-dimensional split-step quantum walks for the L-lattice. We focus on the effect of localization in the above discussed quantum walks. Firstly, we dealt with the effect of trapping i.e. we analyze conditions under which the evolution operator of the walk has non-empty point spectrum. We also study numerically the Anderson localization, in which case we consider static disorder stemming from random phases.

Fast and robust creation of an arbitrary qubit state by nonadiabatic shortcut pulses in a three-level system

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Poster no. 35

Quantum computing is a rapidly growing field with numerous candidates for the qubits used in the physical realization. In our work, we use spin states of Pr^{3+} ions doped into inorganic crystals. More specifically, our qubits consist of an ensemble of 'identical' ions differing only by a spread in resonance frequency of $\approx 200kHz$. A challenge now is to put all these billions of ions in exactly the same superposition state although their frequencies are slightly different. Irrespective of the physical system under concern, an important step in quantum computing and quantum control is to be able to initialize qubits in a short time, with high fidelity. They also need to be robust against inevitable imperfections in the system such as frequency inhomogeneity in atomic transitions, phase errors as well as light intensity fluctuations. In 2008, arbitrary superposition rare earth qubit states were generated with four adiabatic two-color pulses [Rippe, et al., Phys. Rev. A 77, 022307 (2008)] with a fidelity of 90%-95%. Here, we significantly improve on those results by introducing a protocol to design a single two-color resonant nonadiabatic shortcut pulse, capable of creating an arbitrary superposition qubit state that reduces the operation time by 4 times. The preliminarily estimated fidelity is 98%. These pulses are also robust against frequency detuning as high as $\pm 300kHz$, which ensures uniform control on the ensemble of qubit ions. The present approach is not limited to rare-earth doped crystals but can be generalized to any quasi three-level system.

Quantum Dynamical Entropy for Qutrits: beyond rank-1 POVMs

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Poster no. 36

Successive measurements are performed on a finite-dimensional quantum system that evolves unitarily between two consecutive measurements. Such a process, which produces sequences of measurement outcomes and generates a Markov chain in the space of quantum states, can be modelled by a Quantum Iterated Function System. The irreducible randomness of the outcomes is quantified by the dynamical entropy, which is expressed by the Blackwell integral formula, whose evaluation requires the investigation of the Markov chain generated by the system. If the measurement is a (normalized) rank-one POVM, then a closed-form formula for dynamical entropy can be derived. In general, however, no effective formula for dynamical entropy is known. We compute entropy in the case of qutrits measured with a PVM containing a rank-two projector by classifying the possible types of Markov chain such a system generates and deriving for each chain type a closed-form formula for dynamical entropy.

Towards a sharper formulation of the uncertainty principle with majorization in phase space

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Poster no. 37

Information theory can be used to define an entropic uncertainty principle, which is stronger than Heisenberg uncertainty principle. Recently, it has been conjectured that the entropy of non-negative Wigner distributions has a lower bound. Here, we apply the theory of majorization in phase space to present an even strong conjecture. We conjecture that the Wigner distribution of vacuum majorizes every non-negative Wigner distribution. We present some preliminary results towards a proof.

Phase sequence for a robust optomechanical cooling

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Poster no. 38

In this work we demonstrate robust optomechanical cooling by using a phase-tailored sequence on the driving of an optomechanical system (OMS). We study its lossy dynamics, under strong laser driving, by using the quantum Langevin equations for the ladder operators. These equations resemble those of the complex-valued probability amplitudes of a lossless qubit. Using this link, we propose a quantum control technique on OMS, which is inspired by those techniques in lossless qubits: the application of composite pulse sequences with appropriately chosen phases. We found, even in the presence of losses, a robust cooling of the mechanical element of the OMS. Finally, we analyzed numerically the effect of smooth phase changes on the steady state of the system.

Using hierarchical compressed sensing for blind quantum tomography

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Poster no. 39

The task of blind calibration is to simultaneously determine an unknown quantum state and calibrate a partly unknown measurement device eliminating the need for a fully trusted measurement device. Here, we take first steps towards devising a blind calibration scheme by modeling the problem as follows: The data are represented by a sum of potential measurements, only one or few of which are active in any fixed setup, applied to an unknown low-rank quantum state. To solve this blind calibration problem we build on results on blind demixing of hierarchically sparse signals from compressed sensing. Specifically, we prove a recovery guarantee for a hard-thresholding algorithm, which takes into account the hierarchical structure of our signal – a block-sparse vector containing few low-rank blocks. We demonstrate the performance of the algorithm under a Gaussian measurement model and explore its potential for the blind-calibration task on various toy models.

Nonclassical light in the quantum dynamics of mesoscopic spin ensembles

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Poster no. 40

Mesoscopic spin ensembles coupled to a cavity offer the exciting prospect of observing complex nonclassical phenomena with features intermediate between that of single spins and of macroscopic spin ensembles. To unravel the full quantum dynamics and photon statistics of the mesoscopic spin-cavity systems, we present a time-adaptive variational renormalization group method that accurately captures the underlying Lindbladian dynamics. We demonstrate how the collective interactions in an ensemble of as many as 100 spins, arranged in a spectral frequency comb, can be harnessed to obtain a periodic pulse train of sub-Poissonian, nonclassical light.

RNG: QRNG: Many outputs are not enough - input size limits genuine quantum randomnes

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Poster no. 41

The aim is to give a fundamental bound on the randomness that can be generated by a semi-device and device independent approach. We consider extremal Positive Operator Valued Measure (POVM)'s living in the space spanned by the preparations and show that the maximal min-entropy Hmin achievable depends only on the number of preparations and is given by $log_2(d + 1)$.