Thao Le: Discord-breaking and discord-annihilating channels

Entanglement-breaking channels destroy entanglement between bipartite systems by local application onto one of the systems [1, 2]. Entanglement-annihilating channels [3, 4, 5] act across multipartite systems and destroy entanglement across partitions within those systems. Analogously discord-breaking channels act locally on a bipartite system and destroy quantum discord, such that the output state is classical-quantum [6, 7].

Here, we complete the characterisation of discord-breaking channels, by highlighting that zero-discord states are asymmetric. Hence, the class of channels that are discord-breaking on the preferred ("classical") subsystem is different from the channels that are discord-breaking on the non-preferred ("quantum") subsystem. Prior works only considered the former class, which are commutativity creating channels, i.e. quantum measurements with classical output. We find that the latter class are precisely point channels, re-preparing the state on the non-preferred subsystem.

We then introduce and characterise discord-annihilating channels which act on a bipartite system to destroy the quantum discord within the system. We find that these channels are similarly asymmetric, and involve either commutativity creating on the preferred system, re-preparation on the non-preferred subsystem, or some hybrid combination of the two.

This work leads to an improved understanding of zero-discord states and the channels that create them. Furthermore, given that the loss of discord is a key part in the quantum-to-classical transition, this work opens up the possibility of exploring the transition in finer detail via precise classes of quantum channels.

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Soro Gnatiessoro: Imaging quantum correlations through a scattering medium

We report photon-counting imaging of entangled photon-pairs of high Schmidt number transmitted through a scattering medium lying either in the near-field or in the far-field of the entangled photons source. We demonstrate that spatial momentum or position quantum correlations, measured between twin images recorded onto two separate detectors, exhibit in both cases speckle patterns. Moreover, the total correlation is only slightly lowered by the scattering.

Tanmoy Biswas: Operational relevance of resource theories of quantum measurements

For any resource theory it is essential to identify tasks for which resource objects offer advantage over free objects. We show that this identification can always be accomplished for resource theories of quantum measurements in which free objects form a convex subset of measurements on a given Hilbert space. To this aim we prove that every resourceful measurement offers advantage for some quantum state discrimination task. Moreover, we give an operational interpretation of robustness, which quantifies the minimal amount of noise that must be added to a measurement to make it free. Specifically, we show that this geometric quantity is related to the maximal relative advantage that a resourceful measurement offers in a class of minimal-error state discrimination (MESD) problems. Finally, we apply our results to two classes of free measurements: incoherent measurements (measurements that are diagonal in the fixed basis) and separable measurements (measurements whose effects are separable operators). For both of these scenarios we find, in the asymptotic setting in which the dimension or the number of particles increase to infinity, the maximal relative advantage that resourceful measurements offer for state discrimination tasks.

Márcio Mendes Taddei: Exposure of subtle quantum nonlocality in multipartite scenarios

The traditional definition of multipartite Bell nonlocality allowed for a contradictory effect whereby local operations create nonlocality between two parts of the system seemingly from scratch. The inconsistency lied in that arbitrary fine-tuned bilocal hidden-variable models (which exploit hidden signaling) were naively regarded as incompatible with genuinely multipartite nonlocality. This led to a redefinition, according to which, the conflicting models are allocated a subtle form of the resource, which is exposed – as opposed to created – by the local operations. However, such effect has been neither experimentally confirmed nor theoretically explored for other variants of quantum nonlocality, including the celebrated quantum steering of Schrödinger, Einstein, Podolsky, and Rosen. Here we study both Bell nonlocality and steering exposure as resource-theoretic transformations, and theoretically predict the existence of subtle steering, as well as present protocols for its exposure. Surprisingly, the output of such protocols can not only present steering but also Bell nonlocality. We refer to this as super exposure of Bell nonlocality. In addition, we present an operationally consistent redefinition of steering. Finally, we report the experimental demonstration of steering exposure as well as Bell non-locality super-exposure with three photonic qubits and no post-selection. This represents the first experimental confirmation of quantum nonlocality exposure and constitutes also an operational detection of hidden signaling.

Maciej Stankiewicz: Semi-device independent quantum money

The seminal idea of quantum money not forgeable due to laws of Quantum Mechanics proposed by Stephen Wiesner, has laid foundations for the Quantum Information Theory in early '70s. Recently, several other schemes for quantum currencies have been proposed, all however relying on the assumption that the mint does not cooperate with the counterfeiter. Drawing inspirations from the semi-device independent quantum key distribution protocol, we introduce the first scheme of quantum money with this assumption partially relaxed, along with the proof of its unforgeability. Significance of this protocol is supported by an impossibility result, which we prove, stating that there is no both fully device independent and secure money scheme. Finally, we formulate a quantum analogue of the Oresme-Copernicus-Gresham's law of economy.

Marie Ioannou: Quantum random number generator in a prepare-and-measure scenario with the overlap assumption

The aim is to discuss semi-device independent schemes to generate randomness with the prepare-and-measure scenario. The assumption used to restrict the communication between Alice and Bob in order to get quantum correlations is based on the pairwise overlaps between the quantum states emitted by Alice. The idea behind this assumption is physically well motivated when considering optical implementations. First, we want to present practical protocols for quantum random number generation (QRNG). Second, we will show that the amount of randomness which can be generated with such protocols is limited by the number of inputs. This bound on the randomness applies also to complete device-independent scenarios.

Tamoghna Das: Upper bounds on secure key against non-signaling adversary via non-signaling squashed secrecy monotones

We provide upper bounds on device independent key secure against a non-signaling adversary (NSDI) achieved by a class of operations, currently used in both quantum and non-signaling device independent protocols. As the main tool, we introduce a family of measures of non-locality by "squashing" secrecy monotones known to upper bound secret key in the secret key agreement scenario. In particular a squashed secret key rate can be considered itself as an upper bound on the key in NSDI, however, we construct a much more computable example: the non-signaling squashed intrinsic information of a conditional distribution (called squashed non-locality). We prove that the squashed non-locality exhibits several useful properties such as convexity, monotonicity, additivity on the tensor product of conditional distributions, and asymptotic continuity. Hence, as a measure of non-locality, is interesting on its own. We demonstrate this approach by numerical upper bounds on this measure, that suggests, in particular, that the non-locality and secrecy in NSDI are not equivalent. We construct explicit examples of a conditional distribution violating CHSH inequality, from which no key in NSDI can be obtained with direct measurements and public communication followed by classical post-processing. We define the secret key rate in terms of the complete extension, a counterpart of quantum purification in non-signaling scenario, recently introduced in Winczewski et al. [arXiv:1810.02222]. We show that the presented approach is equivalent to the already existing ones, including the one by Hänggi, Renner and Wolf [EUROCRYPT, 2010]. Finally, we simplify the class of operations attaining maximal distinguishability of two devices with several unary inputs, and one input of arbitrary cardinality, which is of independent interest on its own in the context of Generalized Probability Theories.

Fattah Sakuldee: The relation between dynamical pulse processes and sequential measurements and its application in noise spectroscopy

We discuss the effects of a dynamical decoupling sequence of unitary operations and a sequence of projective measurements acting on a qubit in an open quantum system. We demonstrate a formal expression for the equivalence between unitary operations from a minimal set of identity operation and π-rotation about the x-axis in the Bloch sphere, and the sequence of projective measurements of observable concerning the axis of the rotation. Employing this relationship we show that the expectation of the last measurement from a sequence of multiple projective measurements, can be written as a linear combination of expectation values of measurement results observed after subjecting the qubit to dynamical decoupling sequences of pulses, with some of them applied at subsets of these times; and vice versa. From these results, we show theoretically how a correlation of multiple measurements on a qubit undergoing pure dephasing can be expressed as environmental noise filtering. Measurement of such correlations can be used for environmental noise spectroscopy, and the family of noise filters achievable in such a setting is broader than the one achievable with a standard approach, in which dynamical decoupling sequences are used.

Jing Yan Haw: Machine learning cryptanalysis of a quantum random number generator

Random number generators (RNGs) that are crucial for cryptographic applications have been the subject of adversarial attacks. These attacks exploit environmental information to predict generated random numbers that are supposed to be truly random and unpredictable. Though quantum random number generators (QRNGs) are based on intrinsic indeterministic nature of quantum properties, the presence of classical noise in the measurement process compromises the integrity of a QRNG. In this work, we develop a predictive machine learning analysis to investigate the impact of deterministic classical noise in different stages of an optical continuous variable QRNG. Our machine learning (ML) model successfully detects inherent correlations when the deterministic noise sources are prominent. After appropriate filtering and randomness extraction processes are introduced, our QRNG system, in turn, demonstrates its robustness against ML. We further demonstrate the robustness of our machine learning approach by applying it to uniformly distributed random numbers from the QRNG and a congruential RNG. Hence, our result shows that machine learning has potentials in benchmarking the quality of RNG devices.

Armin Tavakoli: Measurement incompatibility and steering are necessary and sufficient for operational contextuality

Contextuality is a signature of operational nonclassicality in the outcome statistics of an experiment. This notion of nonclassicality applies to a breadth of physical phenomena. Here, we establish its relation to two fundamental nonclassical entities in quantum theory; measurement incompatibility and steering. We show that each is necessary and sufficient the failure of operational contextuality. We exploit the established connection to contextuality to provide a novel approach to problems in measurement incompatibility and steering.

Faraj Bakhshinezhad: Energetic cost of creation of correlation

Correlations lie at the heart of almost all scientific predictions. It is therefore of interest to ask whether there exist general limitations to the amount of correlations that can be created at a finite amount of invested energy. Within quantum thermodynamics such limitations can be derived from first principles. In particular, it can be shown that establishing correlations between initially uncorrelated systems in a thermal background has an energetic cost. This cost, which depends on the system dimension and the details of the energy-level structure, can be bounded from below but whether these bounds are achievable is an open question. Here, we put forward a framework for studying the process of optimally correlating identical (thermal) quantum systems. The framework is based on decompositions into subspaces that each support only states with diagonal (classical) marginals. Using methods from stochastic majorisation theory, we show that the creation of correlations at minimal energy cost is possible for all pairs of three- and four-dimensional quantum systems. For higher dimensions we provide sufficient conditions for the existence of such optimally correlating operations, which we conjecture to exist in all dimensions.

Andrés Agustí Casado: Entanglement through qubit motion and the dynamical Casimir effect

We explore the interplay between acceleration radiation and the dynamical Casimir effect in the field of superconducting quantum technologies, analyzing the generation of entanglement between two qubits by means of the dynamical Casimir effect in several states of qubit motion. We show that the correlated absorption and emission of photons are crucial for entanglement, which in some cases can be linked to the notion of simultaneity in special relativity.

Shubhayan Sarkar: Self-testing of maximally entangled state of arbitrary local dimension

Bell nonlocality as a tool for device independent certification schemes has been studied extensively in recent years. The strongest form of device independent certification is known as self-testing, which given a device certifies the promised quantum state as well as the quantum operations without any knowledge of the internal workings of the device. In recent years there has been a wave of results presenting self-testing protocols for various composite quantum systems and measurements. However, it remains a highly nontrivial problem to propose a certification scheme of d-dimensional quantum states based on violation of a single d-outcome Bell inequality. Here we address this problem and propose a self-testing protocol for the maximally entangled state of any local dimension. Further, we self-test using minimum of measurements possible, i.e., 2 per site and self-test d-outcome CGLMP measurements. Our self-testing result can be used to establish unbounded randomness expansion from quantum correlations which is $\log_2 d$ of perfect randomness, while it requires one random bit to encode the measurement choice.

Debashis Saha: Self-testing of quantum devices based on quantum contextuality

The recent rapid development of quantum technologies such as cryptographic systems, quantum simulators orcloud-enabled quantum computing devices poses a fundamental question: Should the back-end user of quantumdevices trust that they exploit quantum phenomena in their functioning and cannot be simulated by purely classical methods? Or, How the back-end user can ultimately ensure that the quantum devices work as specified by theprovider? Methods to certify that a quantum device really operates in a nonclassical way are therefore needed. One of them, developed quite recently in the cryptographic context, is self-testing. Thus, it has been extensively studied over the last few years. However, since the usual self-testing exploits nonlocality (or, in other words quantum correlationsthat violate Bell inequalities), it is restricted to preparations of composite quantum systems and local measurementson them and cannot be used to characterize single quantum systems that are not composite. A recent study shows that to overcome this difficulty one can use contextuality, another nonclassical effect predicted by quantum theory. While the nonlocal correlations are obtained by performing local measurements on spatially separated subsystemsof a composite system, "quantum contextuality" (in particular measurement contextuality) captures a broader classof non-classical correlations obtained from the statistics of measurements that are sequentially performed on a single quantum system. Since quantum contextual correlations have been shown to be the essential in many aspects of quantum computation and information processing, self-testing statements are crucial for certifying quan-tum technology. Apart from that it is, nonetheless, fundamentally interesting to seek the maximum information onecan infer about the quantum devices only from the observed statistics in a contextual experiment. In this work, we provide an analytical formulation to self-testing of single-system preparations and measurementsbased on quantum contextual correlation. Our analytic approach is relied on the "sum-of-square" decomposition ofthe quantum operator associated with the non-contextuality inequality which is introduced for the first time in thecontext of sequential quantum correlation. We consider the simplest so-called n-cycle scenario with n binary outcome measurements and present a modified version of KCBS non-contextuality inequality along with its sum-of-square decomposition. We further obtain a set of algebraic relations involving the quantum stateand measurements that yield the maximum violation of the respective non-contextuality inequality and prove theuniqueness of quantum state and measurements upto the relaxation of local unitaries (i.e., self-testing statement) for the 5-cycle scenario. This work opens up a new avenue of self-testing from the perspective of methodology as well as implication.

Filip Sośnicki: Spectral manipulation of photon pairs by electro-optic time-lensing system

One of the key ingredients for optical quantum information processing is the ability to control the mode structure of quantum light. Experimentally it is well developed for the polarization, path or transverse spatial degrees of freedom. However these are often not compatible with already existing telecom fiber network or limit the accessible number of quantum bits that can be encoded in a single photon. Recently much effort has been directed towards shaping the time-frequency (TF) structure of quantum light pulses. Such manipulations require unitary, phase-only operations, which can be implemented by electro-optic temporal phase modulation and by dispersive propagation, e.g. in an optical fiber. We combine these transformations to achieve coherent spectral shear or spectral bandwidth compression, i.e. narrowing the spectrum while conserving the total energy, which is not possible with filtering. Using two of such transformations enables to manipulate a joint spectral intensity of photon pairs produced eg. by spontaneous parametric down-conversion. We experimentally show a 7-fold bandwidth compression of both photons from photon pair by using electro-optic time lensing system. Our results indicate that such time lensing system may be used to shape entangled photon pairs for quantum information processing in time-frequency degree of freedom.

Veronika Baumann: Page-Wootters conditional probability interpretation and the quantum measurement problem

The tension between unitary Schrödinger evolution and "collapse" dynamics given by the measurement-update rule, called the "measurement problem", becomes manifest in the Wigner's-friend gedankenexperiments [1]. An observer, the friend (F), performs a measurement on a particle. A second observer, Wigner (W), measures F and the particle, which are treated as a joint quantum system. While F applies collapse dynamics and computes subsequent probabilities using the updated state, for W the particle and F undergo unitary evolution. This scenario –and recent extensions [2-4]– leads to the paradox of F and W assigning different probabilities to the same measurement outcome. We propose to apply the Page-Wootters conditional probability interpretation (CPI) of quantum mechanics [5] to Wigner's-friend scenarios. The CPI promotes time to a dynamical variable, leading to a Hamiltonian constraint $H|\psi\rangle = 0$. The physical state $|\psi\rangle$ is assigned to a clock system C and system S and gives conditional probabilities of measurement outcomes performed on S, given that C reads a particular time. The time evolution of S is recovered as a feature emerging from the entanglement between C and S. We show that there exist more than one way to assign two-time conditional probabilities in the CPI framework [6,7], which are reduced to standard quantum mechanics for non-Wigner's-friend scenarios. Depending on the choice of Born rule, however, the Wigner's friend gedankenexperiment gives probability assignments that resemble either "collapse" or full unitary evolution [8], thus resolving the paradox. Moreover, the formalism seems to impose a limit to the possible joint probabilities that can be meaningfully assigned.

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Michał Studziński: Mathematical aspects of port-based teleportation scheme

The port-based teleportation (PBT) protocol introduced in 2008 by Ishizaka and Hiroshima is a variant of quantum teleportation scheme which transmits the unknown state to the receiver without requiring any corrections on his/her side. It is in the opposite to the standard setting presented by Bennett et al. where a correction in a form of rotation has to be applied by the receiver to obtained state. Regardless of the version of the PBT scheme the lack of mentioned correction allows for many important applications such as engineering efficient protocols for instantaneous implementation of measurements and computation, communication complexity, some implications on limitations on quantum channels discriminations, and quantum messages compression.

In our work we disscuss a connection of all variants of PBT with recently studied, by the authors, the algebra of partially transposed permutation operators. In particular we focus on the key innovation which is theory of partially irreducible representation – a new tool for efficient computing products of operators which possess partial symmetries. These tools allow us to present the full analysis of the performance of PBT schemes, like entanglement fidelity or probability of success of the protocol, in the purely group-theoretical manner. Additionally, we present the first result on PBT symulation by projective measurements. We prove a negative result showing that in the class containing the optimal POVMs we cannot construct von Neumann measurements.

Martin Malachov: Time evolution enhanced chaos in purification proto cols

Purification protocols have recently offered a new view on iterational nonunitary manipulation of quantum states. Research showed that particular protocols can give a rise to surprising rich regimes of chaotic dynamics which may be robust to external noise. We now study new modifications to the original protocol which can be understood e.g. as the original protocol enhanced by an additional free time evolution of the physical state between the protocol iterations. We examine asymptotical regimes with respect to newly introduced protocol parameters showing that many settings yield equivalent dynamical regimes. A deeper connection between induced fractal structures and the parameters of the protocol is revealed. These findings have a potential to be used in future quantum networks and communication channels for the purposes of entanglement distillation or quantum state discrimination.

Jakub Czartowski: Iso-entangled mutually unbiased bases, symmetric quantum measurements and mixed-state designs

Discrete structures in Hilbert space play a crucial role in finding optimal schemes for quantum measurements. We solve the problem whether a complete set of five iso-entangled mutually unbiased bases exists in dimension four, providing an explicit analytical construction. The reduced matrices of the 20 pure states forming this generalized quantum measurement form a regular dodecahedron inscribed in a sphere of radius $\sqrt{3/20}$ located inside the Bloch ball of radius 1/2. Such a set forms a mixed-state 2-design — a discrete set of quantum states with the property that the mean value of any quadratic function of density matrices is equal to the integral over the entire set of mixed states with respect to the flat Hilbert-Schmidt measure. We establish necessary and sufficient conditions mixed-state designs need to satisfy and present general methods to construct them. These peculiar constellations of density matrices constitute a class of generalized measurements with additional symmetries useful for the reconstruction of unknown quantum states. Furthermore, we show that partial traces of a projective design in a composite Hilbert space form a mixed-state design, while decoherence of elements of a projective design yields a design in the classical probability simplex.

Adrian Solymos: Extendability of generalised Werner-states

Unlike classical states, quantum states cannot necessarily be extended in such a way that the two-particle reduced states are all identical. More precisely, only the separable states are those that can be extended in such a way. The so-called shareability or extendability number describes to how many parties a given state can be extended to. This is a good entanglement measure (i.e., a LOCC-monotone function), however, it has been calculated only for a few types of states. The poster presents the calculation of this quantity for a new family of states, using group theoretic methods.

Nikolaos Kollas: Non-catalytic extraction of quantum coherence

We present a novel method for extracting the coherence present in a larger system to a smaller subsystem of interest by constructing a unitary interaction which conserves the total amount of coherence for the combined system. We then provide explicit analytic and numerical calculations for a number of examples in which the system acting as the source of quantum coherence is respectively in a coherent and a squeezed state of the harmonic oscillator as well as a finite dimensional maximally coherent and spin coherent state.

Thomas Purves: Nonclassically causal correlations without backwards-in-time signaling

We investigate the relationship between no-backwards-in-time signalling and classically causal correlations. We discover that, unlike the case for two parties, the no-backwards-in-time signalling paradigm for three parties is not enough to ensure that correlations can be reproduced with a classical causal ordering. We demonstrate this with an explicit example. We also generalise some existing results for linear two-time states to multiparty scenarios.

Grzegorz Rajchel: In search for 36 entangled officers of Euler

We investigate branch of combinatorics which proves to be useful for quantum information, specifically in search for Absolutely Maximally Entangled states of local dimension 6. This can be achieved by considering generalization of famous Euler problem. We found improvement, as well as answers to some questions posed before [Phys. Rev. A 72, 012314 (2005)].

Eric Arrais: Efficient certification of shallow circuit preparations

Quantum many-body states are resources for different tasks in quantum information science. Some of such resource states can be prepared by shallow quantum circuits, that is, circuits with a depth that is a constant in the number of subsystems composing the full many-body system. Here, we develop a method to certify the set of states preparable by constant-depth circuits through the so-called ground-state witnesses, i.e., observables that provide a tight lower-bound between their ground-states, the target resource state, and an arbitrary state preparation. The witness developed is efficient, which means that it can be estimated from a subexponential number of observables. Our finding can be used to certify the set of mixed states that are also prepared by shallow circuits, with a major application to the important problem of Gibbs sampling from one-dimensional spin-chain Hamiltonians.

Rafael Santos: Bell-inequalities for high-dimensional graph-states

In this work we constructed Bell-inequalities that are maximally violated by multipartite graph-states in every prime dimension d. These inequalities consist of d measurements in two parts and 2 measurements in the remainings. The Bell-Operator was conveniently constructed taking in account the stabilizer formalism of the graph-states and we could find too a explicit Sum of Squares (SOS) for the Bell-Operator. For dimension 3, the maximal violation of the proposed Bell-inequalities self-test the graph-states.

Marcin Karczewski: Genuine multipartite indistinguishability and its detection via the generalized Hong-Ou-Mandel effect

It is well known that three parties can be entangled in such a way that they are not separable with respect to any bi-partition. Such correlations are called genuinely multipartite, which reflects the fact that they cannot be understood by merely looking at two subsystems. Can an analogous feature be observed for indistinguishability?

In the paper [Phys. Rev. A 99, 042102] this question is addressed by studying the behavior of three entangled distinguishable particles cast on a symmetric 3-port. If their state is totally symmetric, they behave like bosons and in case it is antisymmetric, like fermions. Both these states correspond to effective multipartite indistinguishability which is not genuine – if any pair of the particles was cast on a beam-splitter, it would perfectly bunch or antibunch, just like identical particles.

However, it is possible to imagine an entangled state possessing some tripartite symmetry, but lacking any bipartite one. In this poster, we investigate such states and study their behavior on multiports.

Ryszard Kukulski: Generating random quantum channels

In this work we study the techniques of generating random quantum channels. We present three possible approaches and show that each of them leads to the flat measure. We analyzed some properties of random channels: behavior of the invariant state, capacity and Lipschitz constant. Furthermore, we apply proposed methods to sample generic random networks and discuss their

Edgar Aguilar: Entanglement certification without fidelities

We describe a set of bipartite entangled quantum states whose entanglement cannot be certified via pure fidelity-type entanglement witnesses. We term these states "unfaithful", and provide a SDP characterization. We further show that using pure fidelity-type witnesses to certify multidimensional entanglement (Schmidt rank) also fails to certify many natural states. Finally, we show that it is possible to activate two unfaithful states which are not reducible, to a state which could be certified with a pure fidelity-type witness.

Philip Taranto: Memory effects in quantum processes

Understanding temporal processes and their correlations in time is of paramount importance for the development of near-term technologies that operate under realistic conditions. Capturing the complete multi-time statistics defining a stochastic process lies at the heart of any proper treatment of memory effects. This is well-understood in classical theory, where a hierarchy of joint probability distributions completely characterises the process at hand. However, attempting to generalise this notion to quantum mechanics is problematic: observing realisations of a quantum process necessarily disturbs it, breaking an implicit, and crucial, assumption in the classical setting. This issue can be overcome by separating the experimental interventions from the underlying process, enabling an unambiguous description of the process itself and accounting for all possible multi-time correlations for any choice of interrogating instruments.

Using a novel framework for the characterisation of quantum stochastic processes, we have solved the long standing question of unambiguously describing the memory length of a quantum processes. This is achieved by constructing a quantum Markov order condition that naturally generalises its classical counterpart for the quantification of finite-length memory effects. As measurements are inherently invasive in quantum mechanics, one has no choice but to define Markov order with respect to the interrogating instruments that are used to probe the process at hand: different memory effects are exhibited depending on how one addresses the system, in contrast to the standard classical setting. We can also fully characterise the structural constraints imposed on quantum processes with finite Markov order, shedding light on a variety of memory effects that can arise through various examples. Lastly, we have introduced an instrument-specific notion of memory strength that allows for a meaningful quantification of the temporal correlations between the history and the future of a process for a given choice of experimental intervention.

These findings are directly relevant to both characterising and exploiting memory effects that persist for a finite duration. In particular, immediate applications range from developing efficient compression and recovery schemes for the description of quantum processes with memory to designing coherent control protocols that efficiently perform information-theoretic tasks, amongst a plethora of others.

Libor Caha: Very entangled spin chains and combinatorial techniques in condensed matter physics

(partially based on arXiv: 1805.07168 and additional results)

How entangled can a ground state of a simple quantum matter be? It turns out that a power law violation of entanglement entropy for translationally invariant spin chains with a reasonable energy gap is possible, as one could see for Motzkin spin-2 [PNAS 201605716 (2016)] and Fredkin spin-3/2 chains (with next-nearest-neighbor interaction) [Phys. Rev. B 94, 155140 (2016)].

In [arXiv: 1805.07168], we demonstrate that one can find such surprising properties even in spin-1 chains (qutrits on a line). There we presented the pair-flip (PF) model, a translationally invariant spin chain with an inverse polynomial energy gap, $\sqrt{N}$ half-chain entanglement entropy scaling for a particular ground state on N sites and conjectured that the ground state can be made unique by adding a small perturbation while retaining the entropy (a partial analytical result).

Relying on combinatorial techniques, we study the properties of the PF model ground state further. We use a simple correspondence to relate the entanglement entropy of a middle part (also for Fredkin and Motzkin chains). We derive 1- and 2-point correlation functions and demonstrate a violation of the cluster decomposition property.

Furthermore, we discuss properties of the PF model as well as Motzkin and Fredkin spin chains with periodic boundary conditions, and how we can make their ground states unique (we can no longer use end-point terms in Motzkin and Fredkin chains).

Fredkin, Motzkin, and PF models belong to a class of “rewriting” Hamiltonians, whose ground space can be understood in terms of rewriting rules. For completeness, we enumerate all such 1D Hamiltonians with qubits and show that most of them have ground states in the form of product states only.

David Jakab: Entanglement shareability and mean-field models

It is well-known that de Finetti theorems provide lower bounds on the ground-state energy of quantum spin models defined on complete graphs. We sharpen these bounds using new results about entanglement shareability. Furthermore, this method is also generalized to include models defined bipartite complete graphs. Explicit examples are given for the case of spin-1 bilinear-biquadratic and SU(3)-symmetric spin models.

Michał Banacki: Quantum Markovianity revised

Quantum Markovian evolution is usually defined either by the notion of CP-divisibility of dynamical maps [1, 2] or by the idea of negative flow of information [3]. However, none of this approaches seems to fully grasp the concept of Markovian dynamics. We show that current definitions of Markovianity need a certain reformulation. As a result, we propose some improvements in that area and we discuss several examples illustrating advantages of our new approach [4].

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Viktor Nordgren: Global properties from their absences locally in Gaussian multipartite entanglement

What can we say about the properties of a global system when we only have knowledge of its parts? We present work on a specific aspect of the so-called quantum marginal problem linking the presence of genuine multipartite entanglement on a state with the correlations of the two-state subsystems; with the twist of requiring separability of all two-party reductions and without knowledge of all those correlations. We investigate the continuous-variable scenario in dealing with Gaussian states to complement work done on qubit entanglement [1,2]. Combining two semidefinite programs we find covariance matrices whose genuine multipartite entanglement is detected by a witness, on covariance matrices, which is 'blind' to correlations between two of the modes. This work shows that there are Gaussian states whose multipartite entanglement may be inferred from its two-body reductions even when these are not entangled. Being able to determine multipartite entanglement by looking at a subset of the system could prove useful for tasks in quantum information.

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Mahasweta Pandit: On k-uniform mixed states

We investigate the maximum purity that can be achieved by k-uniform mixed states of N parties. Such N-party states have the property that all their k-party reduced states are maximally mixed. A scheme to construct explicitly k-uniform states using a set of specific N-qubit Pauli matrices is proposed. We provide several different examples of such states and demonstrate that in some cases the state corresponds to a particular orthogonal array. The obtained states, despite being mixed, reveal strong non-classical properties such as genuine multipartite entanglement or violation of Bell inequalities.

Zsombor Szilágyi: Rigidity and a common framework for mutually unbiased bases and k-nets

Many deep, mysterious connections have been observed between collections of mutually unbiased bases (MUBs) and combinatorial designs called k-nets (and in particular, between *complete* collections of MUBs and finite affine — or equivalently: finite projective — planes). Here we introduce the notion of a k-net over an algebra $\mathfrak{A}$ and thus provide a common framework for both objects. In the commutative case, we recover (classical) k-nets, while choosing $\mathfrak{A} := M_d(\mathbb{C})$ leads to collections of MUBs.

A common framework allows one to find shared properties and proofs that "inherently work" for both objects. As a first example, we derive a certain rigidity property which was previously shown to hold for k-nets that can be completed to affine planes using a completely different, combinatorial argument. For k-nets that cannot be completed and for MUBs, this result is new, and, in particular, it implies that the only vectors unbiased to all but $k \leq \sqrt{d}$ bases of a complete collection of MUBs in $\mathbb{C}^d$ are the elements of the remaining k bases (up to phase factors). In general, this is false when k is just the next integer after $\sqrt{d}$; we present an example of this in every prime-square dimension, demonstrating that the derived bound is tight.

As an application of the rigidity result, we prove that if a large enough collection of MUBs constructed from a certain type of group representation (e.g. a construction relying on discrete Weyl operators or generalized Pauli matrices) can be extended to a complete system, then in fact *every* basis of the completion must come from the same representation. In turn, we use this to show that certain large systems of MUBs cannot be completed.

Andrés Felipe Ducuara García: Locally inaccessible maximally hidden quantum correlations

In this work we prove, modulo two conjectures of the quantum steering ellipsoid being true, the existence of the phenomenon of locally inaccessible hidden quantum correlations, that is, the existence of two-qubit states whose hidden quantum correlations cannot be revealed by local filters being implemented on only one side of the experiment, but that can still be revealed when both parties cooperate in applying judiciously chosen local filters. We provide a necessary criterion for guaranteeing the presence of such phenomenon for arbitrary two-qubit states, criterion which in turn relies on two conjectures of the quantum steering ellipsoid being true. These two conjectures although lacking of an analytical proof, are strongly supported by numerical results. We use this necessary criterion to explicitly show examples of two-qubit states with locally inaccessible hidden quantum correlations and furthermore, two-qubit states with locally inaccessible maximally hidden quantum correlations. The quantum correlations here considered are; the violation of the CHSH-inequality for Bell-nonlocality, and the violation of the so-called F_3-inequality for EPR-steering.

Thais Lima Silva: Mutual unbiasedness of coarse-grained measurements for an arbitrary number of phase space observables

Position and momentum eigenbases are mutually unbiased. In terms of measurements, it means that a system prepared in a position eigenstate has equal probability to be measured with any momentum value and vice versa. In practice, the finite width of the detectors and the lack of infinite squeezing preclude the observation of this relation. Actually, not only position and momentum but any two no-parallel directions of phase space are mutually unbiased. This unbiasedness in phase space can be recovered by making periodic coarse-grained measurements. In this work, we show how to simultaneously satisfy the unbiasedness condition between measurements for an arbitrary number of directions in phase space. We also show an experimental confirmation of unbiasedness using the transverse degrees of freedom of photons.

Tomasz Linowski: Entangling power of tripartite unitary gates

We study the entangling properties of tripartite unitary gates with respect to the measure of entanglement τ_1, or one-tangle. We derive the analytical expression for the entangling power of a tripartite gate as an explicit function of the gate, linking the entangling power of gates acting on tripartite Hilbert space of dimension $d_1 d_2 d_3$ to the entanglement of states in the Hilbert space of dimension $(d_1 d_2 d_3)^2$. Furthermore, we study mean and maximum entangling power of unitary gates of an arbitrary, fixed size and relate the latter to the absolutely maximally entangled (AME) states. Finally, we provide a detailed analysis of the entangling properties of three-qubit unitary gates.

Jakub Borkała: Multiparty quantum random access codes

Random access code (RAC), a primitive for many information processing protocols, enables one party to encode n-bit string into one bit of message such that another party can retrieve partial information of that string. We introduce the multiparty version of RAC in which the n-bit string is distributed among many parties. For this task, we consider two distinct quantum communication scenarios: one allows shared quantum entanglement among the parties with classical communication, and the other allows communication through quantum channel. We present several multiparty quantum RAC protocols that outclass its classical counterpart in both the aforementioned scenarios.

Paulina Lewandowska: Benchmarking NISQ devices

The main goal of this work is to introduce a new benchmark for NISQ devices based on the problem of single-shot discrimination of von Neumann measurements. As an example of potential applications, we use our algorithm to benchmark the Rigetti architecture based on criteria like single-qubit gate errors, multi-qubit gate errors, coherence times, the amount of entanglement

Namrata Shukla: Quantum tetrachotomous states: Superposition of four coherent states on a line in phase space

The well-studied quantum optical Schrödinger cat state is a superposition of two distinguishable states, with quantum coherence between these macroscopically distinguishable states being of foundational and, in the context of quantum-information processing, practical use. We refer to these quantum-optical cat states as quantum dichotomous states, reflecting that the state is a superposition of two options, and we introduce the term quantum multichotomous state to refer to a superposition of multiple macroscopically distinguishable options. For a single degree of freedom, such as position, we construct the quantum multichotomous states as a superposition of Gaussian states on the position line in phase space. Using this nomenclature, a quantum tetrachotomous state (QTS) is a coherent superposition of four macroscopically distinguishable states. We define, analyze, and show how to create such states, and our focus on the QTSs is due to their exhibition of much richer phenomena than for the quantum dichotomous states. Our characterization of the QTS involves the Wigner function, its marginal distributions, and the photon-number distribution, and we discuss the QTS's approximate realization in a multiple-coupled-well system.

Jebarathinam Chellasamy: Superunsteerability as a quantifiable resource for random access codes assisted by Bell-diagonal states

We show how nonclassical correlations in local bipartite states can act as a resource for quantum information processing. Considering the task of quantum random access codes (RAC) through separable Bell-diagonal states, we demonstrate the advantage of superunsteerability over classical protocols assisted with two-bits of shared randomness. We propose a measure of superunsteerability, which quantifies nonclassicality beyond quantum steering, and obtain its analytical expression for Bell-diagonal states in the context of the two- and three-setting steering scenarios that are directly related to the quantum $2 \to 1$ and $3 \to 1$ RAC protocols, respectively. The maximal values of our quantifier yield the optimal quantum efficiency for both of the above protocols, thus showing that superunsteerability provides a precise characterization of the nonclassical resource for implementing RACs with separable Bell-diagonal class of states.

Woong-Seon Yoo: New proof and Bell-like inequalities of Arrow's impossibility theorem

A new proof of Arrow's impossibility theorem is given on voting Hilbert Space: no-cloning theorem is equivalent to Arrow's impossibility theorem. The large limits of Arrow scenario based on Landauer's principle are calculated which explain non-dictatorship on infinite voters and options.Arrowian Bell-like inequalities are also proposed. As a result, the analogy between game theory andquantum theory is highlighted.

Gaël Massé: Hybrid entanglement witness

The goal of this work is to implement an entanglement witness (EW) on a given optical hybrid system, i.e one that encodes information with discrete and continuous degrees of freedom. Both regime present specific advantages and drawbacks, and the hybrid approach aims at delivering protocols with better efficiencies and fidelities. Although these states can be completely characterized with full tomographies, these process are costly both in terms of time and computation. Hence, it can be useful to focus our study on the detection of entanglement only, since it constitutes the major ressource of quantum information, provided this involves far less measurements. This is the purpose of EW. These mathematical operators divide the set of quantum states into two parts, the separable states being always on one side, and the targeted entangled state on the other. We present a realistic noise model for an experiment and study how entanglement evolves with regard to it. In particular, we take support from the fact that the state stays in a finite dimension basis to find an entanglement witness that is robust to noise, within current precision of state-of-the-art apparatus. We then cast the witness into observables that are measurable using homodyne detectors, by showing that a well chosen combination of ladder operators can emulate a Pauli like algebra on the continuous-variables side.

Oleg Skachko: Economic rationale of introduction of quantum technologies for protection of data in companies, enterprises and organizations

This article describes the new actions aimed at the formation and improvement of the ability to compete with Russian enterprises and the economic feasibility of the implementation of quantum technologies for data protection in companies, organizations and enterprises. As an example, the system of quantum key distribution (SQDK) and its profitability of the implementation of quantum key distribution systems in enterprises, allowing minimal changes to the existing architecture of information exchange.. The role of the State in the development of conditions for innovative activity in the field of quantum technologies for subsequent implementation in the organization is indicated. The analysis of quantum key distribution systems (SQDK), with the identification of their advantages and disadvantages in terms of development and maintenance of sustainable competitiveness of the economy of subjects, achieved through a fundamentally new way of information security, as well as the features of quantum cryptography in general.

Konrad Szymański: Applications of geometry of density matrices

The set of mixed quantum states, being a subset of unit trace Hermitian operators, has nontrivial geometrical features dependent on the dimensionality of the system in question. Some of its properties can be analyzed by low dimensional projections, allowing for development of uncertainty relations[1] or entanglement criteria[2], among others. The projections, called joint numerical ranges, are of interest on their own as well: they have been studied both from theoretical[3] and experimental[4] standpoint.

In the poster we present the recent developments of theory and applications of joint numerical ranges, including previously unknown theoretical bounds for planar squeezing variance[5], an algorithm establishing entanglement witnesses from arbitrary observables and classification of 3-D projections of qutrit quantum states.

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Filip Rozpedek: Near-term repeater experiments with NV centers: overcoming the limitations of direct transmission

Quantum channels enable the implementation of communication tasks inaccessible to their classical counterparts. However, in the absence of quantum repeaters the rate at which these tasks can be performed is dictated by the losses in the quantum channel. In practice, channel losses have limited the reach of quantum protocols to short distances. Quantum repeaters have the potential to significantly increase the rates and reach beyond the limits of direct transmission. We propose four quantum repeater schemes and assess their ability to generate secret key when implemented on a setup using NV centers in diamond with near-term experimental parameters. We find that one of these schemes surpasses the capacity - the highest secret-key rate achievable with direct transmission - establishing it as a prime candidate for the experimental realization of a scalable quantum repeater.

Behnam Tonekaboni: Quantum noise spectroscopy beyond stationary assumption

The implementation of quantum technologies demands exquisite control over quantum systems subject to noise. Thus, understanding such noise, to a high degree of detail, is vital. To this end, in recent years, a variety of quantum noise spectroscopy protocols have been developed to extract the statistical properties of the noise affecting a quantum system. Here we report on our progress on a new type of noise spectroscopy protocol, that overcomes many of the main limitations of existing protocols, most notably allowing us to characterise non-stationary noise for the first time. We introduce the new theoretical tools we developed in this context as well as an illustrative numerical example.

Shiladitya Mal: Fine grained uncertainty limits preparation contextually

Optimal success probability of a communication game reveals the fundamental limitations of an operational theory. Quantum advantage of parity oblivious random access code (PORAC), a communication game, over classical resources reveals the preparation contextuality of quantum theory [Phys. Rev. Lett. 102, 010401 (2009)]. Optimal quantum bound for N-dit PORAC game for any finite dimension was an open prob- lem. Here, we show that the degree of uncertainty allowed in an operational theory determines the amount of preparation contextuality. We connect the upper bound of fine-grained uncertainty relation to the success prob- ability of PORAC game played with quantum resource. Subsequently, we find the maximal quantum bound for N-dit PORAC game i.e., maximal quantum violation of preparation noncontextuality inequality. Finally we compare maximal quantum violation of some preparation noncontextuality inequalities derived earlier for low dimensions with our result.