Monday

Jens Eisert, FU Berlin (Germany)
Title: Towards certifiable quantum advantages of quantum devices
Abstract: Quantum devices promise computational speedups over classical computers. Fully fletched fault tolerant quantum computers, once achieved, allow to solve some problems in polynomial time that are believed to be intractable on quantum computers. They do not exist yet, however, despite recent progress in experimental realizations. What does exist are quantum simulators - large scale quantum devices providing new insights into dynamical and static properties of complex quantum systems. There is already some good evidence that quantum simulators have the potential to outperform classical computers. Yet, in order to be prone against arguments claiming a lack of imagination, this superior computational capabilities should be expressed in terms of notions of computational complexity.
One of the main milestones in quantum information science is hence to realize quantum devices that exhibit an exponential computational advantage over classical ones without being universal quantum computers in complexity theoretic terms, a state of affairs dubbed exponential quantum advantage. In this talk, we will discuss several surprisingly simple and physically plausible schemes that once realized show such a quantum advantage. Both aspects of physical implementation are discussed as well as mathematical arguments used in proofs relating to notions of computational complexity. We will see that while there is good evidence that these devices computationally outperform classical computers, they can still be efficiently and rigorously certified in their trustworthy functioning, in an error detecting fashion. While full fault tolerance seems out of scope for such architectures, basic variants of approximate error correction are still conceivable. The discussed schemes are experimentally implementable and if time allows, we will discuss data from a proof-of-principle experiment involving trapped ions.

Richard Kueng, Caltech (USA)
Title: Recovering quantum gates with few average fidelities
Abstract: Characterizing quantum processes is a key task for the development of quantum technologies, especially at the noisy intermediate scale of today's devices. One method for characterizing processes is randomized benchmarking, which is robust against state preparation and measurement (SPAM) errors. A complementing approach asks for full tomographic knowledge. Compressed sensing techniques achieve full tomography of quantum channels essentially at optimal resource efficiency. We attempt to combine the favorable features of both worlds: For multi-qubit unitary gates, we provide a practical (full) tomography method that works with an essentially optimal number of average gate fidelities measured with respect to random Clifford unitaries.

Lucas Chibebe Céleri, UFG (Brazil)
Title: A phase-space perspective on entropy production
Abstract: Quantifying the degree of irreversibility of an open system dynamics represents a problem of both fundamental and applied relevance. Even though a well-known framework exists for thermal baths, the results give diverging results in the limit of zero temperature and are also not readily extended to nonequilibrium reservoirs, such as dephasing baths. Aimed at filling this gap, in this paper we introduce a phase-space-entropy production framework for quantifying the irreversibility of spin systems undergoing Lindblad dynamics. The theory is based on the spin Husimi-Q function and its corresponding phase-space entropy, known as Wehrl entropy. We also show that the entropy production of a quantum system undergoing open-system dynamics can be formally split into a term that only depends on population unbalances, and one that is underpinned by quantum coherences. This allows us to identify a genuine quantum contribution to the entropy production in non-equilibrium quantum processes.

Raniery Nery, UFRJ (Brazil)
Title: Advances in Quantum Steering theory

Abstract: Nonlocal correlations play a very important role in our understanding of Quantum Theory. Manifest as quantum steering in hybrid scenarios, where not all parties have trusted devices, the capabilities and the structure of this type of correlation are still relatively unexplored. In this talk, we report on our recent contributions to the theory of quantum steering and on their interesting consequences. First, we consider the manipulation of steering as a resource in multipartite setups: We show that steering is a distillable resource and how distillation can be achieved; we also show that the notion of unsteerable systems in the multipartite case is subtler than expected and, if a proper definition is not provided, an apparent activation of steering is achievable from systems with no resource. Experimental results for the former and a proposal for the latter are presented. Finally, we consider a relaxation of the usual restrictions considered in the study of nonlocal correlations and allow output communication from the untrusted party in the steering scenario. We show that the resulting model is actually an extension of the instrumental causal model, native of the field of causal inference, to the quantum realm, thus connecting the seemingly unrelated topics of quantum steering and causal inference. We also demonstrate that, surprisingly, the relaxation of output communication is not enough to capture all correlations presented by isolated quantum systems, proving then that quantum steering is a stronger type of correlation than previously thought. An experiment involving hyperentangled photons was performed, the setup and the experimental results are also presented.

Marcio Mendes Taddei , UFRJ (Brazil)
Title: Causal networks: from comparison to communication to the distillation of causal non-separability
Abstract: In this work we will tackle two problems describable in terms of causal networks. First, we report a result on the comparison of entanglement and classical communication as sources of correlation. This problem bears relation with instrumental causal models, widely used in many different fields. Surprisingly, in the one-sided device independent scenario, entanglement-created correlations cannot always be reproduced with the communication of a classical output. Moreover, we develop a quantification of the non-classical resource in question, and classical communication is not required to reach its maximum. Secondly, we treat causal non-separability, the resource present in developments such as the quantum switch. We show results (in progress) which pave the way for the treatment of causal non-separability as a resource theory, presenting free classes of transformations and showing the ability to distill the resource from many copies into fewer.

Marcelo Paleologo E F Santos, UFRJ (Brazil)
Title: Steady State Entanglement beyond Thermal Limits
Abstract: Classical engines turn thermal resources into work, which is maximized for reversible operations. The quantum realm has expanded the range of useful operations beyond energy conversion, and incoherent resources beyond thermal reservoirs. This is the case of entanglement generation in a driven-dissipative protocol, which we hereby analyze as a continuous quantum machine. We show that for such machines the more irreversible the process, the larger the concurrence. Maximal concurrence and entropy production are
reached for the hot reservoir being at negative effective temperature, beating the limits set by classic thermal operations on an equivalent system.

Cecilia Cormick, Universidad Nacional de Cordoba (Argentina)
Title: Simulating spin-boson models with trapped ions
Abstract: We propose a method to simulate the dynamics of spin-boson models with small crystals of trapped ions where the electronic degree of freedom of one ion is used to encode the spin while the collective vibrational degrees of freedom are employed to form an effective harmonic environment. The key idea of our approach is that a single damped mode can be used to provide a harmonic environment with Lorentzian spectral density. More complex spectral functions can be tailored by combining several individually damped modes. We propose to work with mixed-species crystals such that one species serves to encode the spin while the other species is used to cool the vibrational degrees of freedom to engineer the environment. The strength of the dissipation on the spin can be controlled by tuning the coupling between spin and vibrational degrees of freedom. In this way the

dynamics of spin-boson models with macroscopic and non-Markovian environments can be simulated using only a few ions. We illustrate the approach by simulating an experiment with realistic parameters and show by computing quantitative measures that the dynamics is genuinely non-Markovian.

Fabricio Macedo de Souza, UFU (Brazil)
Title: Quantum entanglement driven by electron-nanomechanical coupling
Abstract: We study the effects of an effective electron-electron interaction on the formation of entangled states in a two-qubit system, driven by the coupling of electronic states with vibrational modes. The system is composed by four quantum dots separated in pairs, each pair with one excess electron, which is able to tunnel between the dots. Also, the dots from each pair are coupled with different vibrational modes. The combined action of both, this effective interaction and the electronic tunneling explains not only features on the spectrum and the eigenstates of the Hamiltonian, but also the formation of electronic Bell states by exploiting the quantum dynamics of the system.

Raphael Campos Drummond, UFMG (Brazil)
Title: A Shielding Property for the Quantum Ising Model
Abstract: We shall discuss the following property of the inhomogeneous transverse Ising chain equilibrium states, valid for any temperature: whenever the field in one particular site of the chain is null, the reduced state to the left (or to the right) of that site is the Gibbs state of that region. In particular, the reduced state is independent of the parameters of the model on the other side of the site. Furthermore, we discuss conditions that may allow (or not) to generalize the property to more general lattices.

Tuesday

Laura Mancinska, University of Copenhagen (Denmark)
Title: Quantum-inspired relaxations of graph isomorphism
Abstract: We introduce a nonlocal game that captures and extends the notion of graph isomorphism. This game can be won in the classical case if and only if the two input graphs are isomorphic. Thus, by considering quantum strategies we are able to define the notion of quantum isomorphism. We also consider the case of more general non-signalling strategies, and show that such a strategy exists if and only if the graphs are fractionally isomorphic. We prove several necessary conditions for quantum isomorphism, including cospectrality, and provide a construction for producing pairs of non-isomorphic graphs that are quantum isomorphic.
We then show that both classical and quantum isomorphism can be cast as feasibility programs over the completely positive and completely positive semidefinite cones respectively. This leads us to considering relaxations of (quantum) isomorphism arrived at by relaxing the cone to either the doubly nonnegative (DNN) or positive semidefinite (PSD) cones. We show that DNN-isomorphism is equivalent to the previous defined notion of graph equivalence which can be tested in polynomial time. Finally, we show that all of the above mentioned relations form a strict hierarchy of weaker and weaker relations, with non-singalling/fractional isomorphism being the weakest. The techniques used are an interesting mix of algebra, combinatorics, and quantum information.
This is a joint work with Albert Atserias, Robert Šamal, David Roberson, Simone Severini, and Antonios Varvitsiotis.

Lukasz Rudnicki, Max Planck for the Science of Light, Germany
Title : Mutual Unbiasedness in Coarse-Grained Phase-Space Variables
Abstract : Mutual unbiasedness is established for periodic coarse grainings of position and momentum, and is further extended to more than two phase-space variables. Results are illustrated through optics experiments, using the fractional Fourier transform. Our findings decrease the gap between continuous and discrete quantum mechanics and could be useful in quantum information.

Marco Túlio Coelho Quintino , University of Tokyo (Japan)
Title: Quantum protocol for universal inverting general unitary operations
Abstract: Reversible transformations play an important role in mathematics and in various physical theories such as quantum mechanics and thermodynamics. By definition, every reversible transformation has an inverse operation associated to it but, under some physical constraints, constructing these inverse operations may be a highly non-trivial task. This work addresses the question of how one can transform a general reversible quantum operation into its inverse with an operation-independent protocol. Consider the scenario where one has k uses of an arbitrary d-dimension unitary operation which, apart from its dimension, no description of its representation is known. Is it possible to extract a single use of its inverse operation? For any particular operation whose description U_d is known, one can always, in principle, construct the particular inverse operation described by U_d^{-1} . But the situation changes dramatically when we consider a universal method that deals with arbitrary, potentially unknown, unitary operations. Here we prove that a universal method to invert arbitrary unitary operations can never be deterministic and any probabilistic protocol using the unitary operation less than d − 1 times has necessarily zero probability of success. We then present two probabilistic heralded protocols that succeed in this task when k>=d − 1 calls are allowed: a non-adaptive one that uses the unitary operations in parallel and an adaptive one that explores the operations sequentially. For the qubit case we show that our non-adaptive protocol attains the maximal success probability which is given by p = k/(3+k). We also analyse optimality for general qudits on both protocols via semidefinite programming methods and discuss the expected behaviour on the asymptotic limit.

Ariel Bendersky, Universidad de Buenos Aires (Argentina)
Title: Informational principles for non-local correlations based on sequences
Abstract: One long standing question on quantum non-locality is the quest for an informational principle explaining quantum correlations. Many candidates for such a principle have been proposed with partial success, but none fully explaining quantum correlation. Most of these principles rely on the analysis of the multipartite conditional probabilities. In this talk I will briefly review a few results we had when, instead of analysing multipartite probabilities, we analysed sequences of results from non-local boxes (namely, that non-local deterministic boxes cannot be computable, and that pseudorandom inputs allow for a local model explaining non-local correlations), and then I will show how knwon informational principles can inspire us to create new informational principles based on sequences.

Gabriel Ignacio Senno, ICFO (Spain)
Title: Large Bell violations from communication complexity gaps
Abstract: One of the strongest techniques to prove lower bounds on classical communication complexity is the so-called partition bound. In this talk, I will show how to derive large Bell violations from any communication task for which the quantum communication complexity is smaller than the partition bound value. Unlike prior constructions, our result applies to all the quantum advantages appearing in the literature: Disjointness, Vector in Subspace, Tribes, etc. The violations that we get can be exponential in the size of the inputs. Additionally, the quantum distributions achieving them satisfy that: 1) they have the same number of inputs as the original communication complexity problem and only one additional output per party , 2) the local dimension of the quantum states giving rise to them is, at most, linear in the number of inputs and 3) they are robust to uncolored noise and detector inefficiency.

Roberto Serra, UFABC (Brazil)
Title: Controlling the thermodynamic arrow of time in quantum systems
Abstract: Irreversibility is a longstanding puzzle in physics. While microscopic laws of motion are invariant under time reversal, all macroscopic phenomena have a preferred direction in time. Heat, for instance, spontaneously flows from hot to cold. Eddington has called this asymmetry the arrow of time. At the phenomenological level, the second law of thermodynamics allows one to predict which processes are possible in nature: only those with non-negative mean entropy production do occur.

The fact can challenge by employing information about microscopic degrees of freedom in Maxwell's demon scenario or by employing non-classical correlations. We will present some experiments that apparently challenge the second law of thermodynamics at quantum scale and discuss resource employed to literally reversing the arrow of time. These will be associated with a generalized view of the second law of thermodynamics in the presence of initial correlations or when we have access to microscopic information about the system.

Mirjam Weilenmann, University of York (UK)
Title: Smooth entropy in axiomatic thermodynamics
Abstract: Thermodynamics can be formulated in either of two approaches, the phenomenological approach, which refers to the macroscopic properties of systems, and the statistical approach, which describes systems in terms of their microscopic constituents. We establish a connection between these two approaches by means of a new axiomatic framework that can take errors and imprecisions into account. This link extends to systems of arbitrary sizes including microscopic systems, for which the treatment of imprecisions is pertinent to any realistic situation. Based on this, we identify the quantities that characterise whether certain thermodynamic processes are possible with entropy measures from information theory. In the error-tolerant case, these entropies are so-called smooth min and max entropies. Our considerations further show that in an appropriate macroscopic limit there is a single entropy measure that characterises which state transformations are possible. In the case of many independent copies of a system (the so-called i.i.d. regime), the relevant quantity is the von Neumann entropy.

Gláucia Murta Guimarães, QuTech – TUDelft (Netherlands)
Title: Anonymous transmission in a quantum network using the W state
Abstract: We consider the problem of anonymously transmitting a quantum message in a quantum network, and analyze the usefulness of the W state for performing this task. We propose a protocol and analyze its performance in a realistic quantum network, i.e. a network where some form of noise is present. We compare the performance of our protocol to some of the existing protocols developed for the task of anonymous transmission, which make use of GHZ states or Bell pairs as resources. We recognize that, given success in the protocol, our protocol tolerates more noise than the other ones. Moreover, we prove security of our protocol in a semi-active adversary scenario, meaning that we consider active adversary and trusted source.

Flavio Baccari, ICFo (Spain)
Title: Bell correlations depth in many-body systems (2nd week)
Abstract: While the interest in multipartite nonlocality has grown in recent years, its existence in large quantum systems is difficult to confirm experimentally. This is mostly due to the inadequacy of standard multipartite Bell inequalities to many-body systems: such inequalities usually rely on expectation values involving many parties and require an individual addressing of each party. A recent work [J. Tura et al. Science 344, 6189 (2014)] proposed simpler Bell inequalities overcoming such difficulties, opening the way for the detection of Bell correlations with trusted collective measurements through Bell correlation witnesses [R. Schmied et al. Science 352, 441 (2016)], hence demonstrating the presence of Bell correlations with assumptions on the statistics. In this talk (based on the results in [F. Baccari et al. arxiv:1802.09516]), I will address the question of assessing the number of particles sharing genuinely nonlocal correlations in a multipartite system. This endeavour is a priori challenging, as known Bell inequalities for genuine nonlocality suffer from the above shortcomings, plus a number of measurement settings scaling exponentially with the system size. I'll first show that most of these constraints drop once the witnesses corresponding to these inequalities are expressed: in systems where multipartite expectation values can be evaluated, these witnesses can reveal genuine nonlocality for an arbitrary number of particles with just two collective measurements. I'll then introduce a general framework focused on two-body Bell-like inequalities and show that they also provide information about the number of particles that are genuinely nonlocal. Moreover, I'll show how to provide witnesses of Bell correlation depth $k \leq 6$ for any number of parties, within experimental

reach.

Ivan Šupić, ICFo (Spain)
Title: Quantifying teleportation and estimating entanglement from teleportation experiments
Abstract: In this talk I will discuss the problem of quantifying non-classical teleportation. Taking into account the central role of quantum teleportation in various quantum information protocols, it is very important to improve ways of certifying and estimating its non-classical character. Following the approach from [Phys. Rev. Lett. 119, 110501] we have defined non-classical teleportation as one that cannot be simulated classically. The task of certifying non-classical character of teleportation is facilitated by using the full data available in an experiment, instead of characterising the quantumness of teleportation by a single figure of merit, such as average fidelity of teleportation. Two different types of quantifiers are considered here, robustness based teleportation quantifiers, and the teleportation weight. We have shown that in those cases where a teleportation assemblage was obtained by applying a full Bell state measurement, and the set of input states is tomographically complete, the different types of teleportation robustness are in fact equal to their corresponding types of entanglement robustness of the shared state. More generally, when it comes to the important task of entanglement quantification we have proven that it is possible to put a lower bound on the amount of entanglement in an entangled state by assessing its role in a teleportation experiment.

Wednesday

Luiz Davidovich, UFRJ (Brazil)
Title: Quantum Metrology: Toward the Ultimate Precision Limits
Abstract: Quantum Metrology concerns the estimation of parameters, like a phase shift in an interferometer, the magnitude of a weak force, or the time duration of a dynamical process, taking into account the quantum character of the systems and processes involved. Quantum mechanics brings in some new features to the process of parameter estimation. The precision of the estimation becomes now intimately related to the possibility of discriminating two different quantum states of the probe corresponding to two different values of the parameter to be estimated. Also, possible measurements must abide by the rules of quantum mechanics. At the same time, quantum properties, like squeezing and entanglement, may help to increase the precision. Recent results demonstrate that hyperentanglement helps to achieve precision beyond the standard limit [1], establish the relationship between quantum metrology and weak measurements [2], and propose a general framework to parameter estimation in open systems [3,4]. This talk will review some recent achievements, involving noisy optical interferometry [3], the quantum speed limit [4], and the detection of weak microwave fields in cavity quantum electrodynamics [5]. For a review, see [6].
[1] S. P. Walborn, A. H. Pimentel, L. Davidovich, and R. L. de Matos Filho, Quantum-Enhanced Sensing from Hyperentanglement, Phys. Rev. A 97, 010301(R) (2018).
[2] G. Bié Alves et al., Achieving metrological precision limits through postselection, Phys. Rev. A 95, 012104 (2017).
[3] B. M. Escher, R. L. de Matos Filho, and L. Davidovich, General framework for estimating the ultimate precision limit in noisy quantum-enhanced metrology, Nature Physics 7, 406 (2011).
[4] M. M. Taddei et al., Quantum speed limit for physical processes, Phys. Rev. Lett. 110, 050402 (2013).
[5] M. Penasa et al., Measurement of a microwave field amplitude beyond the standard quantum limit, Phys. Rev. A 94, 022313 (2016).
[6] L. Davidovich, Lectures at College de France, http://www.college-de-france.fr/site/jean-dalibard/guestlecturer-2016-02-04-11h00.htm

---

Daniel Braun, University Tuebingen (Germany)
Title: Quantum chaotic sensors

Abstract: Quantum metrology has concentrated almost exclusively on using integrable systems as sensors, such as precessing spins or harmonic oscillators prepared in non-classical states. Here we show that large benefits can be drawn from rendering integrable quantum sensors chaotic, both in terms of achievable sensitivity as well as robustness to noise, while avoiding the challenge of preparing and protecting large-scale entanglement. We apply the method to spin-precession magnetometry and show in particular that the sensitivity of state-of-the-art magnetometers can be further enhanced by subjecting the spin-precession to non-linear kicks that renders the dynamics chaotic. [Lukas J. Fiderer and Daniel Braun, Nature Communications 9, 1351 (2018)] .

María José Sánchez, Centro Atómico Bariloche and Instituto Balseiro (Argentina)
Title: Entanglement generation through the interplay of harmonic driving and interaction in coupled superconducting qubits
Abstract: The control of entanglement is one of the central prerequisites of quantum computing architectures in order to exploit the non local quantum correlations. In this talk I will describe the manipulation of quantum entanglement by periodic external fields in coupled superconducting qubits. As an entanglement measure we compute the concurrence when both qubits are driven by a dc+ac external control parameter. We show that when the driving term of the Hamiltonian commutes with the qubit-qubit interaction term, it is possible to create or destroy entanglement in a controlled way by tuning the system at or near multiphoton resonances. On the other hand, when the driving does not commute with the qubit-qubit interaction, the control and generation of entanglement induced by the driving field is more robust and extended in parameter space beyond the multiphoton resonances, being a more convenient situation for practical implementations of driving induced entanglement.

Stefano Paesani, Quantum Engineering Technology Labs, University of Bristol (UK)
Title: High-dimensional quantum information processing with large-scale integrated optics
Abstract: The ability to control high-dimensional quantum systems has interesting applications for the investigation of fundamental science and for the development of advanced quantum technologies. However, so far experimental approaches for the generation and processing of high-dimensional quantum systems have presented significant limitations in terms of controllability, precision and universality, which have represented bottlenecks for further developments of multidimensional technologies. We present a novel approach based on multidimensional integrated quantum photonics for the generation, control and analysis of high-dimensional entanglement. In particular, we report a programmable bipartite entangled system with dimension up to 15 × 15 on a large-scale silicon-photonics quantum circuit. The device integrates more than 550 photonic components on a single chip, including 16 identical photon-pair sources. We verify the high precision, generality and controllability of our multidimensional technology, and further exploit these abilities to demonstrate key quantum applications experimentally unexplored before, such as quantum randomness expansion and self-testing on multidimensional states. Furthermore, we demonstrate the realization of universal operations on a high-dimensional system, and present schemes for generalizing the approach to multipartite multidimensional entangled systems for high-dimensional quantum simulation and computation.

Jessica Bavaresco, Institute of Quantum Optics and Quantum Information (Austria)
Title: Measurements in two baswiees are sufficient for certifying high-dimensional entanglement
Abstract: High-dimensional encoding of quantum information provides a promising method of transcending current limitations in quantum communication. One of the central challenges in the pursuit of such an approach is the certification of high-dimensional entanglement. In particular, it is desirable to do so without resorting to inefficient full state tomography. Here, we show how carefully constructed measurements in two bases can be used to faithfully and efficiently certify high-dimensional states and their entanglement for any physical platform. To showcase the practicality of this approach under realistic conditions, we put it to the test for photons entangled in their orbital angular momentum. In our experimental setup, we are able to verify 8-dimensional entanglement for 11-dimensional subspaces, at present the highest amount certified without any

assumptions on the state.

Stephen Walborn, UFRJ (Brazil)
Title: Quantum-enhanced sensing with Hyperentanglement
Abstract: Hyperentanglement — simultaneous entanglement between multiple degrees of freedom of two or more systems — has been used to enhance quantum information tasks such as quantum communication and photonic quantum computing. Here we show that hyperentanglement can lead to increased quantum advantage in metrology, with contributions from the entanglement in each degree of freedom, allowing for Heisenberg scaling in the precision of parameter estimation. Our experiment employs photon pairs entangled in polarization and spatial degrees of freedom to estimate a small tilt angle of a mirror. Precision limits beyond shot noise are saturated through a simple binary measurement of the polarization state. The broad applicability of the dynamics considered here implies that similar strategies based on hyperentanglement can offer improvement in a wide variety of metrological tasks in a number of physical systems.

Davide Poderini, University of Rome "La Sapienza" (Italy)
Title: Experimental learning of quantum states
Abstract: It is well known that the number of parameters needed to describe a generic quantum state grows exponentially with the number of particles. This exponential scaling, while representing a fundamental resource for quantum computation, can also become an obstacle for some tasks, as quantum tomography. The purpose of quantum tomography is to produce a complete description of a quantum state given the ability to prepare and measure a certain number of its copies. Characterising an unknown quantum state is a fundamental tool in quantum information processing, but unfortunately, for a general n-qubit quantum state, the number of operations needed to recover its description scales exponentially with n. This scaling clearly limits our ability to perform tomography of systems with more than a few qubits.To address this difficulty we can rephrase tomography as a supervised learning problem, in which a learner uses the knowledge of a few measurements, drawn randomly from a certain set, to generate an hypotesis state, and then uses this hypotesis to predict the outcome of any other measurement drawn from the same set. In this context it can be shown that, using only a linear number of measurements, quantum states can be "probably approximately learned" (PAC), i.e. it is possible to predict with high probability the outcome of other measurements with a certain precision [1].
In our work [2] we applied this learning scheme to real optical systems ranging from 2 to 6 qubits, experimentally demostrating for the first time this linear scaling. Our results represent another proof of the power of computational learning methods to investigate quantum information, and pave the way to probing quantum states at new, larger scales.
[1] Aaronson, S. The learnability of quantum states. Proceedings of the Royal Society of London A, 2088, 3089-3114, (2007).
[2] Rocchetto, A., Aaronson, S., Severini S., Carvacho, G., Poderini, D., Agresti, I., Bentivegna, M., Sciarrino, F., Experimental learning of quantum states. ArXiv:1712.00127 (2017).

Gustavo Lima Universidad de Concepcion (Chile)
Title: Experimental Quantum Randomness Generation with Many Outcome Measurements
Abstract: The existence of random processes has applications in many disciplines such as cryptography and simulations of physical, biological, and social phenomena. Here we will present two new approaches for the device-independent generation of random bits based on the use of many outcome quantum measurements. While resorting to qubits, the first approach achieves a gain of 27% of randomness as compared with the standard methods [1]. The second approach relies on the use of qudits and the new implementation of NxN multiport beamsplitter based on multicore fibers [2].
References
[1] S Gómez, A Mattar, ES Gómez, D Cavalcanti, O Jiménez Farías, A Acín, G Lima, Physical Review A 97 040102 (2018).
[2] G Cañas, N Vera, J Cariñe, P González, J Cardenas, PWR Connolly, A Przysiezna, ES Gómez,

M Figueroa, G Vallone, P Villoresi, T Ferreira da Silva, GB Xavier, G Lima, Physical Review A 96, 022317 (2017).

Emanuele Polino, La Sapienza, University of Rome (Italy)

Title: Device independent certification of a quantum delayed choice experiment

Abstract: From the beginning wave-particle duality was one of the most counterintuitive and debated aspects of quantum theory: a quantum object can behave like a classical particle or wave depending on the measurement apparatus. Wheeler with his Delayed Choice Experiment (DCE), enlightened even more the contrast between classical and quantum theories: after a photon enters in a Mach-Zehnder interferometer, the experimenter chooses to insert or not the second beam splitter revealing the wave or particle behaviour respectively. The goal is to rule out a classical objective description of the duality in which a quantum system is intrinsically either a wave or a particle. However the original proposal of the DCE and its quantum version depend on strong and unclear assumptions on the objective Hidden Variable models that intend to rule out. On the other hand Causal Inference can be used to define and study the testable boundaries between classical and quantum predictions. One can map the DCE into a prepare and measure scenario and study it in a causal framework, as shown by Chaves et al. in "Causal modeling the delayed choice experiment", Physics Review Letters 120, 190401 (2018). In this description, if one relaxes the trivially incompatible assumptions of the DCE, a local classical description exists and explains the quantum predictions. Slightly modifying the DCE, it can be rejected any classical model on which the only assumption is its dimensionality.
Here we implement this modified version of the DCE using a photonic platform and exploiting the polarization degree of freedom of single photons. By violating two dimensional witnesses we experimentally rule out, in a device-independent way, any classical model accounting of the modified DCE. The crucial hypothesis needed to rule out any non retro-causal classical model is the natural assumption that dimensionality of the studied system is 2. One of the two violated dimensional witnesses is detection loophole free, so without assuming fair sampling. The other one, when violated, permits to rule out also models in which correlations between the preparation and measurement devices are allowed.

Friday

Mario Berta, Imperial College London (UK)

Title: Matrix Trace Inequalities for Quantum Entropy

Abstract: Entropy is a fundamental, multidisciplinary concept linking a priori unconnected areas of science such as statistical mechanics, thermodynamics, information theory, and theoretical computer science, well-understood in the case of classical systems. In contrast, when it comes to systems described by quantum mechanics, our knowledge about entropy is still limited. The reason is that multipartite quantum states are entangled and the resulting non-commutativity poses a big challenge for lifting results from the classical to the quantum setting. Entropy inequalities that are known to hold in the non-commutative case give crucial insights into the entanglement structure of multipartite quantum states. I will argue that matrix trace inequalities provide the essential ingredient for understanding quantum entropy and present multivariate trace inequalities that extend the Golden-Thompson and Araki-Lieb-Thirring inequalities as well as some logarithmic trace inequalities to arbitrarily many matrices. From our four matrix extension of the Golden–Thompson inequality, I will then deduce various refined quantum entropy inequalities. The proofs rely on complex interpolation theory, providing a direct approach to treat generic multivariate trace inequalities.

Tobias Fritz, Max Planck Institute for Mathematics in the Sciences (Germany)

Title: Resource theories in quantun information and beyond

Abstract: I will present a general framework for resource theories that applies in and beyond quantum

information, and sketch how to apply it in particular examples. These methods are useful mainly for analyzing the asymptotic structure of a resource theory, such as the computation of rates. I will explain the asymptotic structure of classical and quantum thermodynamics without a background temperature. This includes simple methods for determining e.g. the maximal efficiency of a heat engine operating on finite but large reservoirs. Surprisingly, the reason that a heat engine is possible at all, even in classical thermodynamics, is the same reason as to why a mixed state in quantum theory can generally be written as a mixture of different ensembles of pure states. More generally, I will explain in which sense already classical thermodynamics is a general probabilistic theory. Based on arXiv:1504.03661 and arXiv:1607.01302 (with Carlo Sparaciari and Jonathan Oppenheim).

Daniel Jost Brod, UFF (Brazil)
Title: Classical simulation of photonic linear optics with lost particles
Abstract: In this talk I will discuss a classical simulation scheme for linear-optical experiments subject to particle losses, focusing on under which conditions it is efficient. Concretely, consider the canonical boson sampling scenario in which an n-photon input state propagates through an m-mode linear-optical network and is subsequently measured in the output modes. I will describe simulations of this system based on two models of losses. In the first model, a fixed number of particles is lost, and we show that the output statistics can be efficiently approximated provided the number of photons remaining grows sufficiently slowly. In the second loss model, every time a photon passes through a beamsplitter in the network it has some probability of being lost. For this model the relevant parameter is s, the smallest number of beamsplitters that any photon must traverse. We prove it is possible to approximate the output statistics already if s grows logarithmically with m, regardless of the geometry of the network. The latter result is obtained by proving it is always possible to commute s layers of uniform losses to the input of the network. Finally, I discuss how these findings put limitations on future experimental realisations of quantum computational supremacy proposals based on boson sampling.

Mehmet Burak Sahinoglu, Caltech (USA)
Title: TBA
Abstract: TBA

Felix Huber, University of Cologne (Germany)
Title: Exponentially many monogamy and correlation constraints for multipartite quantum states
Abstract: We present an exponentially large family of correlation constraints that apply to all multipartite quantum systems of finite dimension. These constraints stated in terms of linear entropies or purities of reductions. Our relations are obtained by defining and investigating a generalization of the universal state inversion map. This map can, surprisingly, directly be linked to Rains' shadow inequalities [IEEE Trans. Inf. Theory 46, 54 (2000)]. In case of pure states our correlation constraints turn into monogamy relations that govern the distribution of bipartite entanglement in multipartite quantum systems of finite-dimension.

Gabriela Barreto Lemos, IIP (Brazil)
Title: A causal view on Bell inequality violations using classical optics
Abstract: For twenty years there has been a long standing debate on the interpretations and the practical consequences of non-separability observed in the degrees of freedom of some classical optical beams. These states of light are well-known in classical coherence theory but when their analogy to quantum correlations is emphasized, a seemingly paradoxical scenario is unveiled. Analogies to Bell inequalities have been derived and violated with classical beams, and analogies to quantum protocols such as metrology and local teleportation have been shown to be advantageous. In this talk I will who how causal analysis can help shed light on the physical meaning of these experiments.

Eduardo Inacio Duzzioni , UFSC (Brazil)
Title: Estimating the time evolution of NMR systems via a quantum-speed-limit–like expression
Abstract: Finding the solutions of the equations that describe the dynamics of a given physical system is crucial in order to obtain important information about its evolution. However, by using estimation theory, it is possible to obtain, under certain limitations, some information on its dynamics. The quantum-speed-limit (QSL) theory was originally used to estimate the shortest time in which a Hamiltonian drives an initial state to a final one for a given fidelity. Using the QSL theory in a slightly different way, we are able to estimate the running time of a given quantum process. For that purpose, we impose the saturation of the Anandan-Aharonov bound in a rotating frame of reference where the state of the system travels slower than in the original frame (laboratory frame). Through this procedure it is possible to estimate the actual evolution time in the laboratory frame of reference with good accuracy when compared to previous methods. Our method is tested successfully to predict the time spent in the evolution of nuclear spins 1/2 and 3/2 in NMR systems.We find that the estimated time according to our method is better than previous approaches by up to four orders of magnitude. One disadvantage of our method is that we need to solve a number of transcendental equations, which increases with the system dimension and parameter discretization used to solve such equations numerically.

Leandro Aolita, UFRJ (Brazil)
Title : TBA
Abstract : TBA