Quantum Information Theory and Mathematical Physics 2019

Budapest, 2-5.09.2019

Program

	Monday 02.09	Tuesday 03.09	Wednesday 04.09	Thursday 05.09
9.30 – 10.45	Ivan Todorov	Francesco Buscemi	Mario Berta	Christoph Hirche
10.45 – 11.15	Coffee break			
11.15 – 12.30	András Gilyén	Kamil Korzekwa	Cambyse Rouzé	Péter Vrana
12.30 – 14.30	Lunch			
14.30 – 15.45	Fumio Hiai	Fabien Clivaz		
15.45 – 16.15	Coffee break			
16.15 –	Free discussion, sightseeing, dinner			

Videos: `https://www.dropbox.com/sh/zhpo1ul4iasldnq/AABr-5ZCCcxWL0JJZL7Nb8q0a?dl=0`

Conference dinner:

Time: Wednesday, 04 September, 19:00-21:30
Location: Ape Regina, 1065 Budapest, Podmaniczky u. 18.
http://aperegina.hu/
`https://www.google.hu/maps/place/Ape+Regina+Italian+Restaurant/@47.508596,19.057433,15z/data=!4m2!3m1!1s0x0:0xaf0ce3d58545831b?sa=X&ved=2ahUKEwjog8eo2sTdAhXMp4sKHffbCVgQ_BIwEXoECAcQCw`

Talks

Speaker: Mario Berta

Title: Finite de Finetti Theorems for Quantum Channels

Abstract: Quantum de Finetti theorems are a fundamental tool for studying quantum correlations. Motivated by questions from quantum noisy channel coding, we present novel finite de Finetti theorems for quantum channels, quantifying closeness to the convex hull of product channels as well as closeness to local operations and classical forward communication assisted channels. In turn, this give rise to converging hierarchies of efficiently computable semidefinite programming outer bounds on the optimal fidelity for the transmission of quantum information over noisy quantum channels. The first level of our hierarchies corresponds to the non-signalling assisted fidelity previously studied by [Leung & Matthews, IEEE Trans. Inf. Theory 2015], and positive partial transpose constraints can be added and used to give a sufficient criterion for the exact convergence at a given level of the hierarchy.

Speaker: Francesco Buscemi

Title: The theory of statistical comparison and its applications in quantum information theory

Abstract: The theory of statistical comparison was formulated (chiefly by David Blackwell in a series of papers in the 1950s) as an extension of the theory of majorization to objects beyond probability distributions, like multivariate statistical models and stochastic transitions, and has played an important role in mathematical statistics ever since. The central concept in statistical comparison is the so-called "information ordering," which is formulated in terms of suitably defined statistical decision problems. A very closely related ordering relation independently appeared some time later in information theory, with Shannon's (1958) and Körner's and Marton's (1975) partial ordering of noisy channels. Even though related, the two research lines have been put back in contact only recently. In this talk, after reviewing the basic ideas of statistical comparison in decision theory and in information theory – with an emphasis on their operational character –, I will discuss various generalizations of these ideas to quantum information theory, arguing that quantum statistical comparison provides the natural framework for the formulation of quantum resource theories. Time permitting, I will discuss explicit examples of the use of concepts of statistical comparison in the resource theories of quantum nonlocality, quantum communication, quantum thermodynamics, quantum coherence, and quantum incompatibility.

Speaker: Fabien Clivaz

Title: Thermodynamically optimal creation of correlations

Abstract: 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. In this talk 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.

Speaker: András Gilyén

Title: Quantum Singular Value Transformation & Its Algorithmic Applications

Abstract: In this talk I will introduce a generic quantum algorithmic framework that is called "quantum singular value transformation", capable of working with exponentially large matrices, that can apply polynomial transformations to the singular values of a block of a unitary matrix (corresponding to a quantum circuit). I will show how quantum singular value transformation unifies a large number of prominent quantum algorithms, and sketch some problems where it leads to new quantum algorithms or improves earlier approaches.

Speaker: Fumio Hiai

Title: Generalized Lyapunov equations and optimized measurements

Abstract: `http://math.bme.hu/~mosonyi/QIMP2019/Presentations/Hiai_abstract`

Speaker: Christoph Hirche

Title: Online learning of quantum change points

Abstract: The detection of sudden changes of a stochastic random variable is one of the most fundamental problems in statistical analysis. The task of efficiently and quickly identifying these so called change points motivates its very own field of research. Recently, the idea was generalized to detecting changes in a sequence of, supposedly identical, quantum states. Some first results were achieved considering sequences of pure states and minimum error performance criteria. In practice, it is however often more important to detect changes as soon as possible, while minimizing the rate of false detections. We will describe an extension of the best known classical online change point detection algorithm, CUSUM, to the quantum setting and discuss results concerning the optimal and achievable rates under certain performance criteria. Additionally, we will consider the more general problem of detecting changes in a sequence of quantum channels and, finally, we will discuss open problems that would lead to converse statements under stricter performance criteria.

Speaker: Kamil Korzekwa

Title: Resource-theoretic approach to the thermodynamic arrow of time

Abstract: The first and second law of thermodynamics are fundamental constraints on state transformations, forcing thermodynamic processes to conserve the overall energy and forbidding free conversion of heat into work. In this talk I will present the resource-theoretic framework developed to rigorously study allowed thermodynamic transitions between different non-equilibrium quantum states. I will first describe the basic structure of the thermodynamic arrow of time for classical states, relating the majorization and thermo-majorization partial orders to the concepts of microcanonical and canonical ensembles. Then, I will explain how this relatively simple picture complicates, when one considers transformations between states that are not just mixtures, but superpositions of different energy eigenstates. Finally, I will discuss some of the recent developments and open problems in the field, including finite-size irreversibility effects, the resource resonance phenomenon and the role of memory.

Speaker: Cambyse Rouzé

Title: On the quantum modified logarithmic Sobolev inequality

Abstract: Since the introduction of the H-theorem by Boltzmann in 1872, mathematicians have been interested in quantifying the speed of convergence to equilibrium in relative entropy of physical processes. In some cases –including Markov chains over finite dimensional or lattice spin systems at high enough temperature and diffusion processes over compact Riemannian manifolds with positive Ricci curvature- the convergence can be shown to be exponential in time. Due to the Markovian assumption, the problem of the estimation of the corresponding decay exponent for these cases can be tackled by looking at the infinitesimal decrease of the relative entropy functional along the corresponding Markov semigroup, also known as a modified logarithmic Sobolev inequality (MLSI). Since the discovery of the first MLSI due to Gross in 1975, the field has evolved into a rich and elegant branch of mathematics at the intersection between probability theory, geometry and information theory. Generalization of the framework to the quantum setting started soon after, but suffered an interruption, due to the lack of purely non-commutative tools present at that time. However, recent progress and connections to the fast-growing field of QIT suggest that establishing a fully quantum theory of MLSI is now within reach. In this talk, I will provide a self-contained introduction to the subject. After a brief introduction to the main objects of the theory, I will explain some of the current open problems and advances in the field of MLSI, such as their tensorization property and the so-called Holley-Stroock perturbation argument. If time permits, I will discuss some recent applications to establishing the strong converse property of quantum information theoretical tasks and progress towards establishing the MLSI for quantum Gibbs samplers.

Speaker: Ivan Todorov

Title: Non-commutative graphs: sandwich theorems and capacity bounds.

Abstract: Non-commutative graphs - or, equivalently, operator subsystems of matrix algebras - arise naturally in quantum information theory as confusability graphs of quantum channels and play an important role in questions about zero-error information transmission. As in the classical case, the computation of the Shannon capacity of a non-commutative graph is a difficult problem that leads to the need to introduce easier computable bounds. In this talk, I will summarise some recent developments in this direction. In particular, I will describe non-commutative versions of the vertex packing polytope, the theta convex body and the fractional vertex packing polytope of a graph, and discuss a quantum version of the Sandwich Theorem of Grotschel, Lovasz and Schrijver. This leads to new non-commutative versions of the Lovasz number of a graph and an upper bound of the zero-error capacity of the corresponding quantum channel that can be genuinely better than the one originally established by Duan, Severini and Winter. I will also discuss non-commutative counterparts of several other widely used classical graph parameters and their interrelation.

Speaker: Péter Vrana

Title: Entanglement distillation from Greenberger–Horne–Zeililinger shares

Abstract: Hypergraph tensors are a class of tensors that arise from unit tensors via tensor product and partial flattening. In my talk I will consider asymptotic degenerations between such tensors and in particular explain how to find their asymptotic subranks. In quantum information theory, asymptotic degeneration can be interpreted as asymptotic entanglement transformation by stochastic local operations and classical communication, and these tensors encode a configuration of GHZ states shared by subsets of multiple parties.

Posters

Presenter: Máté Farkas

Title: Incompatibility robustness of quantum measurements: a unified framework

Abstract: One might be tempted to argue that the most important distinction between classical theories and quantum mechanics is the way we model the act of performing a measurement. Classically, a measurement process corresponds to simply revealing an unknown (but pre-existing) value, which leaves the state of the system untouched. In quantum mechanics, on the other hand, performing a measurement is an active and invasive process which (in most cases) disturbs the system. This implies that there exist incompatible quantum measurements, i.e. measurements that cannot be simultaneously performed on a single copy of the system. It is then natural to ask what the most incompatible quantum measurements are. Although several measures have been proposed to quantify how incompatible a set of measurements is, their properties are not well understood. In this work we propose several conditions that a reasonable measure of incompatibility should satisfy and we investigate whether the existing measures comply with those. Quite surprisingly we find that some of the widely used measures do not fulfil these basic requirements. Moreover, we show that when looking for the most incompatible pair of quantum measurements we obtain different (often counter-intuitive) answers depending on the exact measure. This means that we are still far from understanding how to measure the incompatibility of quantum measurements in a meaningful manner. Based on joint work with Sébastien Designolle and Jedrzej Kaniewski, preprint available at: https://arxiv.org/abs/1906.00448.

Presenter: Simon Morelli

Title: Dimensionally sharp inequalities for the linear entropy

Abstract: We derive new dimension dependent inequalities for the Tsallis 2-entropy. These give a sharp upper bound for the entropy of a bipartite system of any dimension.

Presenter: József Pitrik

Title: Barzcenters in quantum information theory

Abstract: `http://math.bme.hu/~mosonyi/QIMP2019/Presentations/Pitrik_abstract`

Presenter: Szilárd Szalay

Title: k-stretchability of entanglement, and the duality of k-separability and k-producibility

Abstract: We briefly review the partial separability based classification of mixed states of multipartite quantum systems of arbitrary number of subsystems. We show how this structure simplifies in the case when not entanglement but correlation is considered. As special cases, we consider the notions of k-separability and k-producibility (as well as their correlational versions), and reveal how these are dual to each other. This can be seen from a much

wider perspective, when we consider the entanglement and correlational properties which are invariant under the permutations of the subsystems. This general treatment reveals a new property, which we call k-stretchability of entanglement, being sensitive in a balanced way to both the maximal size of correlated (or entangled) subsystems and the minimal number of subsystems uncorrelated (or separable) from one another. We also give the corresponding multipartite correlation and entanglement monotones, being the natural generalizations of mutual information, entanglement entropy and entanglement of formation or relative entropy of entanglement, showing the same lattice structure as the classification (multipartite monotonicity). As illustration, we show some examples coming from molecular-physics. The contribution is based on the works [PhysRevA 92, 042329 (2015)], [SciRep 7, 2237 (2017)], [JPhysA 51, 485302 (2018)], and [arXiv:1906.10798 [quant-ph] (2019)].

Presenter: Zsombor Szilágyi

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

Abstract: `http://math.bme.hu/~mosonyi/QIMP2019/Presentations/Szilagyi_abstract`

Presenters: Tamás Tasnádi, Gergely Bunth

Title: Geometric aspects of majorization and catalytic majorization

Abstract: In quantum information theory, quantum thermodynamics, and quantum resource theory, majorization and catalytic majorization have gained great significance. They are preorders on the classical as well as quantum state space, and strongly related to various state convertibility issues. The majorization relation has been studied for a long time, but its catalytic version is still much less understood. We highlight some interesting properties of these relations by studying the geometry of the sets of states (catalytically) majorized by a fixed state.