Program

May 20 (Monday), 2019

Opening (09:00)

09:00 – 10:20

Masahito Hayashi: Asymptotic decoupling property and mixing condition and Hidden Markovian Process in quantum system

Hui Khoon Ng: Noise in open quantum systems

10:40 – 12:00

Yang Yu: On Positive Partial Transpose Squared Conjecture

James A Mingo: The Partial Transpose and its relation to freeness

13:30 – 14:50

Łukasz Pawela: Asymptotic properties of quantum states and channels

Hiroyuki Osaka: Subspaces of maximal dimension with bounded Schmidt rank

15:10 – 16:30

Fumio Hiai: Quantum f-divergences in von Neumann algebras

Min Namkung: Structure of Sequential State Discrimination

16:40 – 17:20

Son: Quantifiable simulation of quantum computation beyond stochastic ensemble computation

May 21 (Tuesday), 2019

09:00 – 10:20

Salman Beigi: Quantum Nonlocality in the Triangle Network

Nilanjana Datta: Quantum Reverse Hypercontractivity and Strong Converses in Quantum Information Theory

10:20 – 12:00

Sergey Filippov: Quantum Sinkhorn's theorem: Applications in entanglement dynamics, channel capacities, and compatibility theory

Yiu-Tung Poon: Evaluating the robustness of **k**-coherence and **k**-entanglement

13:40 – 14:50

Teiko Heinosaari: Noise-disturbance relation and the Galois connection of quantum measurements

Chi-Kwong Li: Operator systems arsing in Quantum Information Science

15:10 – 16:30

Motohisa Fukuda: Weingarten calculus on computers and its application to random quantum Gaussian states

Milan Mosonyi: Divergence radii and the strong converse exponent of classical-quantum channel coding with constant compositions

16:40 – 17:20

Francesco Buscemi: Quantum Statistical Comparison, Quantum Majorization, and Their Applications to Generalized Resource Theories

May 22 (Wednesday), 2019

09:00 – 10:20

Ludovico Lami: Completing the Grand Tour of asymptotic quantum coherence manipulation

Raymond Sze: Operator Quantum Error Correction for Phase-flip Error

10:40 – 12:40

Jaeyoon Cho: Proof of the entanglement area law in one dimension

Ion Nechita: Quantum de Finetti theorems and Reznick's Positivstellensatz

Gilad Gour: Resource theories of quantum processes

May 23 (Thursday), 2019

09:00 – 10:20

Mark Wilde: α-Logarithmic negativity

Jaewan Kim: QuDits; Exponential Function, Coherent States, and Entanglements

10:40 – 12:00

Junghee Ryu: Wringing Out Better No-signaling Monogamies

Daniel McNulty: Measures of Complementarity

13:30 – 14:50

Fang Song: Quantum Pseusorandomness

SangGyun Youn: Temperley-Lieb quantum channels

15:10 – 16:30

Szilard Szalay: On multipartite entanglement and multipartite correlations

Ashutosh Rai: Geometry of the quantum set on no-signaling faces

16:40 – 17:20

Kyung Hoon Han: Order unit norms arising from multi-qubit X-states

May 24 (Friday), 2019

09:00 – 10:20

Young Hoon Kiem: Entangled edge states of corank one with positive partial transposes

Marcin Marciniak: Separability of symmetric states and moment problem

10:40 – 12:00

Eric Chitambar: Measurement Incompatibility and Semi-Quantum Nonlocal Games

Otfried Guhne: Quantum Steering and the Geometry of the EPR-Argument

Abstracts

Salman Beigi (IPM, Teheran, Iran)

Quantum Nonlocality in the Triangle Network

Quantum networks allow in principle for completely novel forms of quantum correlations. In particular, quantum nonlocality can be demonstrated here without the need of having various input settings, but only by considering the joint statistics of fixed local measurement outputs. However, previous examples of this intriguing phenomenon all appear to stem directly from the usual form of quantum nonlocality, namely via the violation of a standard Bell inequality. In this talk novel examples of "quantum nonlocality without inputs" are presented for the triangle network, which we believe represent a new form of quantum nonlocality, genuine to networks. This talk is based on joint works with Marc-Olivier Renou, Yuyi Wang, Elisa Baumer, Sadra Boreiri, Nicolas Brunner and Nicolas Gisin.

Francesco Buscemi (Nagoya University, Nagoya, Japan)

Quantum Statistical Comparison, Quantum Majorization, and Their Applications to Generalized Resource Theories

The theory of statistical comparison was formulated (chiefly by David Blackwell in the 1950s) in order to extend 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," according to which information need not always be a totally ordered quantity, but often takes on a multi-faceted form whose content may vary depending on its use. In this talk, after reviewing the basic ideas of statistical comparison with an emphasis on their operational character, I will discuss various generalizations to quantum theory (and beyond). I will then argue that quantum statistical comparison provides a natural framework, somehow complementary to semi-definite programming, to study quantum resource theories, with explicit examples given by the resource theories of quantum nonlocality, quantum communication, and quantum thermodynamics. The talk is based on joint work with M. Mosonyi.

Eric Chitambar (University of Illinois Urbana-Champaign, Urbana and Champaign, USA)

Measurement Incompatibility and Semi-Quantum Nonlocal Games

Measurement incompatibility, entanglement, and nonlocality are all characteristic features of quantum systems. Typically quantum nonlocality is understood in the context of Bell Inequalities, and it was first shown by Werner that certain entangled states exist that cannot violate a Bell Inequality. Such a result suggests that entanglement and Bell Nonlocality are distinct physical phenomena. Yet, if one moves beyond the setting of Bell nonlocality, Buscemi has shown that all entangled states offer some advantage over separable states in the context of semiquantum nonlocal games. A concept closely related to nonlocality is measurement incompatibility. The violation of a Bell Inequality requires the use of incompatible local measurements. However, the converse is not true and recently certain families of incompatible measurements have been shown to only generate local correlations. In this talk, I will describe how measurement incompatibility can be introduced to the setting of semiquantum nonlocal games. Analogous to Buscemi's result, every family of incompatible measurements will be shown to offer an advantage in semiquantum nonlocal games over local strategies.

Jaeyoon Cho (APCTP, Seoul, Korea)

Proof of the entanglement area law in one dimension

Understanding the universal nature of entanglement in many-body systems is one of the central themes in modern theoretical physics. In this talk, I explain the underlying idea of the proof that in one-dimensional many-body systems in a pure state, the entanglement entropy of an arbitrary continuous region is upper bounded by a constant determined solely by the correlation length.

Nilanjana Datta (University of Cambridge, Cambridge, UK)

Quantum Reverse Hypercontractivity and Strong Converses in Quantum Information Theory

We derive a finite blocklength strong converse for the task of asymmetric quantum hypothesis testing, using the quantum generalization of a novel technique introduced by Liu, Handel and Verdu in the classical setting. This involves the use of a powerful analytical tool, namely, quantum reverse hypercontractivity of a quantum Markov semigroup. This technique can be further generalized to obtain finite blocklength strong converse results for multiuser tasks of quantum network information theory, e.g. distributed hypothesis testing under communication constraints and transmission of information through broadcast channels. This is joint work with Salman Beigi and Cambyse Rouze. Results from two recent papers with Hao-Chung Cheng and Cambyse Rouze will also be touched upon.

Sergey Filippov (Steklov Mathematical Institute, Moscow, Russia)

Quantum Sinkhorn's theorem: Applications in entanglement dynamics, channel capacities, and compatibility theory

The Sinkhorn theorem establishes a relation between the matrix with strictly positive elements X and the doubly stochastic matrix Y in the following way. For every X there exists a unique matrix Y such that $Y = D_1 X D_2$, where D_1 and D_2 are diagonal matrices with strictly positive diagonal elements. Matrices D_1 and D_2 are responsible for a proper normalization of rows and columns, respectively, and can be found in an iterative way. Sinkhorn's motivation for that study was the estimation of a doubly stochastic matrix Y describing a discrete-time Markov chain $\mathbf{p}_{m+1} = Y\mathbf{p}_m$. Here, $\mathbf{p}_m$ is an N-dimensional probability vector describing the state of a classical system at step m. Suppose the Markov chain is governed by a bistochastic matrix Y and one has observed a finite number n_{ij} of transitions from i-th node to j-th node of the graph. Then $X = (n_{ij})_{i,j=1}^N$, and the matrix Y can be found via Sinkhorn's algorithm.

The quantum analogue of a probability distribution $\mathbf{p}$ is a density operator ρ acting on an N-dimensional Hilbert space (positive semidefinite operator with a unit trace). The quantum analogue of the matrix X is a positivity improving map Φ satisfying $\Phi[\rho] > 0$ for all $\rho \geq 0$, which is equivalent to the statement that Φ belongs to the interior of the cone of positive maps. The quantum analogue of the doubly stochastic matrix Y is a unital trace preserving positive map Υ satisfying $\Upsilon[\rho] \geq 0$ and $\mathrm{tr}[\Upsilon[\rho]] = \mathrm{tr}\rho$ for all $\rho \geq 0$.

The quantum Sinkhorn theorem has been formulated in slightly different ways in the papers. We use the following formulation. For every Φ there exist positive definite self-adjoint operators A and B such that

$$\Upsilon = \Phi_A \Phi \Phi_B, \tag{1}$$

where $\Phi_A[\cdot] = A \cdot A^\dagger$ and $\Phi_B[\cdot] = B \cdot B^\dagger$.

If Φ is a quantum operation (trace non-increasing completely positive map), then Υ is a unital quantum channel, i.e. a unital, completely positive, and trace preserving linear map. Therefore, quantum Sinkhorn's theorem allows one to use the results for unital channels in order to make conclusions about quantum operations Φ.

For instance, for unital channels Υ acting on qubits ($N = 2$) the additivity relation for χ-capacity holds and the classical capacity is known. Basing on quantum Sinkhorn's theorem we derive lower and upper bounds on the classical capacity of a general qubit channel Φ. Also, we translate the entanglement-annihilating properties of the two-qubit local channel $\Upsilon_1 \otimes \Upsilon_2$ onto the the general local qubit channels $\Phi_1 \otimes \Phi_2$. As a byproduct, we find an entangled state exhibiting the ultimate robustness to such noises. Surprisingly, the most robust state is not maximally entangled in general.

Further implications are related with the analysis of quantum operations (not channels) that naturally occur in quantum measurements. We consider a situation where an experimentalist has access only to a limited number of degrees of freedom as it takes place, e.g., in measuring orbital angular momentum of light beams. Two parts of the initially entangled state of light ρ_{in} are passed through noisy media, which results in the state $\rho_{\text{out}} = \Phi_1 \otimes \Phi_2[\rho_{\text{in}}]$. Then one has experimental access only to some local degrees of freedom with corresponding projectors P_1 and P_2. The usual way is to consider the conditional outcome state $P_1 \otimes P_2 \rho_{\text{out}} P_1 \otimes P_2 / \text{tr}[P_1 \otimes P_2 \rho_{\text{out}} P_1 \otimes P_2]$. Instead, we focus on an operation $\Phi_{P_1}\Phi_1 \otimes \Phi_{P_2}\Phi_2$ and use quantum Sinkhorn's theorem to find the optimal input state ρ_{in} guaranteeing the highest degree of entanglement in the experimentally accessible subspace.

Finally, quantum Sinkhorn's theorem can be generalized to maps $\Phi : \mathscr{B}(\mathscr{H}_N) \to \mathscr{B}(\mathscr{H}_N) \otimes \mathscr{B}(\mathscr{H}_N)$ with a composite outcome space. We report that this generalization has implications on operational compatibility of quantum operations in analogy with compatibility of quantum channels.

References:

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Motohisa Fukuda (Yamagata University, Yamagata, Japan)

Weingarten calculus on computers and its application to random quantum Gaussian states

Weingarten Calculus shows how to calculate abstractly the average of polynomials of random unitary matrices with respect to the Haar measure. However, for example, if we want to calculate the average of a monomial which has four copies of the same random unitary matrix (and the adjoint) as factors, we need to exhaust 576 cases. In the first half of this talk, we introduce a computer program which assists such abstract calculations. In the second half, we present some example, where this program was used to calculate the forth moment of covariance matrices of random Gaussian states.

Gilad Gour (University of Calgary, Calgary, Canada)

Resource theories of quantum processes

A common theme in Chemistry, Thermodynamics, and Information Theory is how one type of resource – be it chemicals, heat baths, or communication channels – can be used to produce another. These processes of conversion and their applications are studied under the general heading of ”resource theories”. While resource theories use a wide range of sophisticated and apparently unrelated mathematical techniques, there is also an emerging general mathematical framework which seems to underpin all of them. In this talk, I will give a short overview on some of these common mathematical structures that appear in resource theories, particularly those appearing in resource theories of quantum processes. I will focus mainly on resource theories of Bell nonlocality, entanglement, coherence, asymmetry, and athermality.

Otfried Guhne (University of Siegen, Siegen, Germany)

Quantum Steering and the Geometry of the EPR-Argument

Steering is a type of quantum correlations which lies between entanglement and the violation of Bell inequalities. In this talk, I will first give an introduction into the topic. Then, I will discuss three results on steering: First, I will explain the connection to joint measurability. Second, I will show how entropic uncertainty relations can be used to derive steering criteria. Finally, I will present an algorithmic approach to characterize the quantum states that can be used for steering. With this, one can decide the problem of steerability for two-qubit states.

References:

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Kyung Hoon Han (University of Suwon, Suwon, Korea)

Order unit norms arising from multi-qubit X-states

We will discuss separability criteria for general multi-qubit states in terms of diagonal and anti-diagonal entries. We define two numbers which are obtained from diagonal and anti-diagonal entries, respectively, and compare them to get criteria. They give rise to characterizations of separability when all the entries are zero except for diagonal and anti-diagonal. For the three qubit case, it turns out that these two numbers coincide with the quantities in the criteria proposed by O. Gühne in 2011. It seems that it is difficult to express them in analytic formulas in general. In some cases (three qubit, four qubit, GHZ diagonal), they can be computed to algebraic or analytic formulas. We also discuss their relationship to the order unit norms of the tensor products of function systems from the functional analysis viewpoint.

This talk is based on joint works with Lin Chen, Kil-Chan Ha, Seung-Hyeok Kye.

Masahito Hayashi (Nagoya University, Nagoya, Japan)

Asymptotic decoupling property and mixing condition and Hidden Markovian Process in quantum system

First, we focus on mixing property and decoupling for quantum dynamics Mixing property is a useful property for quantum dynamics as well as ergodicity.Decoupling property plays an important role in open quantum systems and quantum information. We show that these two proerties are equivalent to each other for quantum dynamics. Additionally, we derive their necessary and sufficient conditions by using ergodicity. Under these conditions, we have a quantum version of Perron-Frobenius theorem.

Second, we focus on a hidden Markovian process whose internal hidden system is given as a quantum system, and we address a sequence of data obtained from this process. Using a quantum version of Perron-Frobenius theorem, we derive novel upper and lower bounds for the cumulant generating function of the sample mean of the data. Using these bound, we derive the central limit theorem and large and moderate deviations for the tail probability. Then, we give the asymptotic variance is given by using the second derivative of the cumulant generating function. We also derive another expression for the asymptotic variance by considering the quantum version of fundamental matrix. Further, we explain how to extend our results to general probabilistic system.

This is a joint work with Yuuya Yoshida. The detail of the first part is available from arXiv:1801.03988, and that of the second part is from Journal of Physics A: Mathematical and Theoretical, Volume 51, Number 33, 335304 (2018). This is a joint work with Yuuya Yoshida.

Teiko Heinosaari (University of Turku, Turku, Finland)

Noise-disturbance relation and the Galois connection of quantum measurements

The trade-off between noise and disturbance is one of the most fundamental features of quantum measurements. In the two extreme cases a measurement either makes no disturbance but then has to be totally noisy or is as accurate as possible but then has to disturb so much that all subsequent measurements become redundant. Most of the measurements are, however, somewhere between these two extremes. There is a structural correspondence between certain order relations defined on observables and channels that properly explains the trade-off between noise and disturbance. A suitable mathematical framework to investigate the correspondence further is the Galois connection induced by the compatibility relation between channels and observables. Forming the Galois connection gives immediately two closure maps, one on the set of observables and another one on the set of channels. The closure map on the set of observables can be interpreted as a mathematical description of information leak.

Fumio Hiai (Tohoku University, Sendai, Japan)

Quantum f-divergences in von Neumann algebras

We discuss standard f-divergences and maximal f-divergences in general von Neumann algebras, based on Haagerup's L^p-spaces and Araki's relative modular operators. The most important property of these quantum divergences is the monotonicity inequality (or the data-processing inequality) under quantum operations. We revisit Petz' old problem of reversibility of quantum operations between von Neumann algebras via equality in the monotonicity inequality of quantum divergences.

Young Hoon Kiem (Seoul National University, Seoul, Korea)

Entangled edge states of corank one with positive partial transposes

In the current quantum information and computation theory, the notion of entanglement is considered as one of the most important resources. Nevertheless, distinguishing entanglement from separability is very difficult, and known to be NP hard in general. Among various separability criteria, the PPT criterion is very simple to test but powerful: The partial transpose of a separable state must be positive (semi-definite). Of particular interest are some extremal PPT states, called entangled edge states, because all PPT states are convex sums of separable states and edge states.

I will talk about an explicit construction of a parameterized family of $n \otimes n$ PPT states of corank one whose partial transposes have corank 2n-3 for every $n \geq 3$. We checked that these states are in fact entangled edge states, for n up to 1000. We conjecture that they are entangled edge states for all $n \geq 3$. Our states are the first explicit examples of PPT entangled edge states for $n \geq 4$.

Based on a joint work with Jinwon Choi and Seung-Hyeok Kye.

Jaewan Kim (KIAS, Seoul, Korea)

QuDits; Exponential Function, Coherent States, and Entanglements

TBA

Ludovico Lami (University of Nottingham, Nottingham, UK)

Completing the Grand Tour of asymptotic quantum coherence manipulation

We show how to compute on all quantum states several measures that characterise asymptotic quantum coherence manipulation under restricted classes of operations. We focus in particular on the distillable coherence, i.e. the maximum rate of production of approximate pure bits of coherence starting from independent copies of an input state, and on the coherence cost, i.e. the minimum rate of consumption of pure coherence bits that is needed in order to generate many copies of a target state with vanishing error. We obtain the first closed-form expression for the distillable coherence under strictly incoherent operations (SIO), showing that it is the same as that obtained by means of physically incoherent operations (PIO). This remarkable fact shows that SIO and PIO are equally weak as far as distillation is concerned, and sheds light on the recently discovered phenomenon of generic bound coherence. At the same time, it provides us with an explicit optimal distillation protocol that is amenable to practical implementations. On a different line, we also give a single-letter formula for the coherence cost under PIO, showing that it is finite on a nontrivial set of states with nonzero volume that we are able to characterise with precision. Since PIO can be realised in a laboratory by appending incoherent ancillae, performing incoherent unitaries, and making incoherent measurements, our result puts fundamental limitations on coherence manipulation in an experimentally relevant setting. We uncover the phenomenon of abyssally bound coherence under PIO, that is, the existence of states with vanishing PIO distillable coherence yet infinite PIO coherence cost. Our findings complete the picture of asymptotic coherence manipulation under all the main classes of incoherent operations.

Chi-Kwong Li (College of William and Mary, Williamsburg, USA)

Operator systems arsing in Quantum Information Science

An operator system of bounded linear operators acting on a Hilbert space is a self-adjoint subspace containing the identity. We will discuss some recent results and problems concerning the study of operator system associated with quantum channels.

Marcin Marciniak (University of Gdansk, Gdansk, Poland)

Separability of symmetric states and moment problem

We discuss the problem of separability for symmetric multipartial states. In particular we consider a notion of D-symmetry. For a system of N qubits, it coincides with the usual permutational symmetry. In the case of N qudits ($d \geq 3$), the D-symmetry is stronger than the permutational one. For the space of all D-symmetric vectors in $(\mathbb{C}^d)^{\otimes N}$, we define a basis composed of vectors $\{|R_{N,d;k}\rangle : 0 \leq k \leq N(d-1)\}$ which are analogs of Dicke states. The aim of the talk is to show some conditions equivalent to separability of D-symmetric states which are diagonal in the basis $\{|R_{N,d;k}\rangle\}$. Using some classical results about moment problem show that if N is even and $d \geq 2$ is arbitrary then a positive partial transposition property is a necessary and sufficient condition of separability for D-invariant diagonal states.

Daniel McNulty (Aberystwyth University, Wales, UK)

Measures of Complementarity

Pairs of observables in quantum mechanics are complementary if exact knowledge of the measured value of one observable implies maximal uncertainty of the measured value of the other. Perhaps the first formulation of this property was given by Pascual Jordan in 1927: "for a given value of q all values of p are equally possible". The precise mathematical form of complementarity can be described in terms of mutually unbiased bases, which generalises naturally to larger sets of observables in arbitrary dimensions. In this talk we discuss several measures of complementarity which result from different formulations of mutually unbiased bases. We analyse the compatibility of these measures and discuss how they might be applied to solve the existence problem of mutually unbiased bases.

James A Mingo (Queen's University, Kingston, Canada)

The Partial Transpose and its relation freeness

The partial transpose has been an important part of quantum information theory for some time. In 2008 Aubrun showed that in a certain regime it can transform a Marchenko-Pastur distribution into a semi-circular one. More recently Banica and Nechita showed that in a neighbouring regime the partial transpose of a Marchenko-Pastur produced the free difference of two other Marchenko-Pastur distribution. In this talk we shall show how this operator can be applied at the level of operators without going to a random matrix model.

This is based on joint work with Mihai Popa.

Milan Mosonyi (Budapest University of Technology and economics, Budapest, Hungary)

Divergence radii and the strong converse exponent of classical-quantum channel coding with constant compositions

There are different inequivalent ways to define the Rényi mutual information between the input and the output of a channel. In a 1995 paper Csiszár has shown that for classical discrete memoryless channels there is a distinguished such quantity that has an operational interpretation as a generalized cutoff rate for constant composition channel coding. We show that the analogous notion of Rényi mutual information, defined in terms of the sandwiched quantum Rényi divergences, has the same operational interpretation in the strong converse problem of classical-quantum channel coding. Denoting the constant composition strong converse exponent for a memoryless classical-quantum channel W with composition P and rate R as $sc(W,R,P)$, our result is that

$$sc(W,R,P) = \sup_{\alpha>1} \frac{\alpha-1}{\alpha}[R - \chi^*_{\alpha,2}(W,P)],$$

where $\chi^*_{\alpha,2}(W,P)$ is the Augustin-type sandwiched Rényi mutual information between the classical input and the quantum output of the channel for a given input distribution P. Along the way we also prove that this quantity is additive for product channels and product input distributions.

(Joint work with Tomohiro Ogawa)

Min Namkung (Hanyang University, Ansan, Korea)

Structure of Sequential State Discrimination

Sequential state discrimination is that multiparties participate in discriminating a quantum state prepared by a sender. A succesful sequential state discrimination is that every receiver succeeds in discriminating the sender's quantum state when a classical communication is not allowed between receivers. It implies that sequential state discrimination can be used for Muti-party Quantum Key Distribution. In this talk, we describes the stucture of sequential state discrimination. Specially, we discuss the method to generalize sequential state discrimination.

Ion Nechita (Laboratoire de Physique Theorique de Toulouse, Toulouse, France)

Quantum de Finetti theorems and Reznick's Positivstellensatz

We present a proof of Reznick's quantitative Positivstellensatz using ideas from Quantum Information Theory. This result gives tractable conditions for a positive polynomial to be written as a sum of squares. We relate such results to de Finetti theorems in Quantum Information.

Hui Khoon Ng (Yale-NUS College, Singapore,)

Noise in open quantum systems

Open quantum systems – where the interaction of the system with the environment or bath changes the dynamics of the system – form the basis of any realistic quantum information processing architecture. The noise on the system, due to this interaction with the bath, can be described, in many physical scenarios, by the ”standard noise model” of system-only quantum noise channels. In other situations, where non-Markovian effects may be important, one often employs the Hamiltonian noise model, describing joint unitary dynamics of the system together with the bath. More generally, we can describe the noise on the open quantum system as one that originates from a joint quantum channel on the system-bath composite, a framework that includes and interpolates between the two extremes of the standard noise model and the Hamiltonian noise model. In this talk, I will discuss the physical basis for considering such a system-bath joint quantum channel as the source of noise in QIP systems, how to mitigate such noise, as well as how to characterize it.

This talk is based on work with Len Yink Loong [Phys Rev A 98, 022307 (2018)], and with Miko laj Paraniak, and Li Weijun (manuscript in preparation).

Hiroyuki Osaka (Ritsumeikan University, Kyoto, Japan)

Subspaces of maximal dimension with bounded Schmidt rank.

We determine sufficient conditions for certain classes of $(n+k)\times n$ -matrices E to have all order-n minors to be nonzero. For a special class of $(n+1)\times n$ -matrices E, we give the formula for the order-n minors. As an application we construct of subspaces of $\mathbb{C}^m\otimes\mathbb{C}^n$ of maximal dimension, which does not contain any vector of Schmidt rank less than 4.

Co-authorr(s) Priyabrata Bag, Santanu Dey (IIT Bombay), and Masaru Nagisa (Chiba Univ.)

Łukasz Pawela (Institute of Theoretical and Applied Informatics, Polish Academy of Sciences, Gliwice, Poland)

Asymptotic properties of quantum states and channels

Properties of random mixed states of dimension N distributed uniformly with respect to the Hilbert-Schmidt measure are investigated. We show that for large N, due to the concentration of measure, the trace distance between two random states tends to a fixed number $\tilde{D} = 1/4 + 1/\pi$, which yields the Helstrom bound on their distinguishability. To arrive at this result we apply free random calculus and derive the symmetrized Marchenko–Pastur distribution. For quantum channels, we show that their level density is also described by the Marchenko-Pastur distribution. This allows us to deduce some properties of the diamond norm of large dimensional quantum channels and provide a new upper bound on the diamond norm. This results shed new light on the sets of quantum states and channels of large dimension N.

Yiu-Tung Poon (Iowa State University, Ames, USA)

Evaluating the robustness of k-coherence and k-entanglement

It has been asked whether or not two related measures of k-coherence, called the standard and generalized robustnesses of k-coherence, are equal to each other when restricted to pure states. A similar question has also been asked about analogous measures of Schmidt rank k-entanglement when restricted to pure states. We answer both of these conjectures in the affirmative by showing that the standard robustnesses satisfy the same formulas that are known to hold for the generalized robustnesses.

Ashutosh Rai (KAIST, Daejeon, Korea)

Geometry of the quantum set on no-signaling faces

Since Bell's theorem we know that quantum mechanics is incompatible with local hidden variable models, the phenomenon known as quantum nonlocality. However, in spite of steady progress over years, the precise characterization of the set of quantum correlations has remained an elusive quest. There are correlations compatible with the no-signaling principle and still beyond what can be achieved within quantum theory, what has motivated the search for physical principles and computational methods to decide the quantum or post-quantum behavior of correlations. Here we identify a yet new feature of Bell correlations that we call quantum voids: faces of the no-signaling set where all nonlocal correlations are postquantum. Considering the simplest possible Bell scenario we give a full characterization of quantum voids, also understanding its connections to known principles and its potential use as a dimension witness.

Reference: A. Rai, C. Duarte, S. Brito, and R. Chaves, Geometry of the quantum set on no-signaling faces, Phys. Rev. A, 99, 032106; arXiv: 1812.06057 (Dec. 2018)

[Link: https://arxiv.org/abs/1812.06057] .

Junghee Ryu (National University of Singapore, Singapore,)

Wringing Out Better No-signaling Monogamies

We show that simple geometric properties of probabilistic spaces, in conjunction with nosignaling principle, lead to strong monogamies for a large class of Bell type inequalities. Additionally, using the same geometric approach, we derive a new tripartite, d-outcome Svetlichny-Zohren-Gill type Bell inequality and show its monogamous nature.

Wonmin Son (Sogang University, Seoul, Korea)

Quantifiable simulation of quantum computation beyond stochastic ensemble computation

In this study, a distinctive feature of quantum computation (QC) is characterized. To this end, a seemingly-powerful classical computing model, called "stochastic ensemble machine (SEnM)," is considered. The SEnM runs with an ensemble consisting of finite copies of a single probabilistic machine, hence is as powerful as a probabilistic Turing machine (PTM). Then the hypothesis—that is, the SEnM can effectively simulate a general circuit model of QC—is tested by introducing an information-theoretic inequality, named readout inequality. The inequality is satisfied by the SEnM and imposes a critical condition: if the hypothesis holds, the inequality should be satisfied by the probing model of QC. However, it is shown that the above hypothesis is not generally accepted with the inequality violation; namely, such a simulation necessarily fails, implying that PTM $\subseteq$ QC.

Fang Song (Texas A&M University, Collge station, USA)

Quantum Pseusorandomness

In this talk, I'll introduce the concept of pseudorandom quantum states, which appear random to any quantum polynomial-time adversary. This offers a computational approximation to perfect randomness on quantum states (analogous to a cryptographic pseudorandom generator), as apposed to some statistical notion of quantum pseudorandomness in the literature, such as quantum t-designs (analogous to t-wise independent distributions). Joint work with Zhengfeng Ji and Yi-Kai Liu.

Szilard Szalay (Hungarian Academy of Sciences, Budapest, Hungary)

On multipartite entanglement and multipartite correlations

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), reveal how these are dual to each other, and discuss some consequences. 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)] and [JPhysA 51, 485302 (2018)], and on results unpublished yet.

Raymond Sze (The Hong Kong Polytechnic University, Hung Hom, Hong Kong)

Operator Quantum Error Correction for Phase-flip Error

The idea of quantum error correction is to protect quantum information from errors due to decoherence and other quantum noise during the transmission of information in quantum channels. In this talk, we consider the situation when all physical qubits involved in coding suffer from certain phase-flip error. An error correcting scheme and its implementing encoding and decoding circuits for low dimensional quantum system will be presented.

Mark Wilde (Louisiana State University, Baton Rouge, USA)

α-Logarithmic negativity

The logarithmic negativity of a bipartite quantum state is a widely employed entanglement measure in quantum information theory, due to the fact that it is easy to compute and serves as an upper bound on distillable entanglement. More recently, the κ-entanglement of a bipartite state was shown to be the first entanglement measure that is both easily computable and operationally meaningful, being equal to the exact entanglement cost of a bipartite quantum state when the free operations are those that completely preserve the positivity of the partial transpose. In this paper, we provide a non-trivial link between these two entanglement measures, by showing that they are the extremes of an ordered family of α-logarithmic negativity entanglement measures, each of which is identified by a parameter $\alpha \in [1,\infty]$. In this family, the original logarithmic negativity is recovered as the smallest with $\alpha = 1$, and the κ-entanglement is recovered as the largest with $\alpha = \infty$. We prove that the α-logarithmic negativity satisfies the following properties: full entanglement monotone, normalization, faithfulness, and subadditivity. We also prove that it is neither convex nor monogamous. Finally, we define the α-logarithmic negativity of a quantum channel as a generalization of the notion for quantum states, and we show how to generalize many of the concepts to arbitrary resource theories. Joint work with Xin Wang and available at https://arxiv.org/abs/1904.10437

SangGyun Youn (Queen's University, Kingston, Canada)

Temperley-Lieb quantum channels

We introduce a new class of channels, which we call Temperley-Lieb channels, and give a summary of investigated properties. First of all, we explain their highly non-trivial structures, which make discussions quite difficult. For example, most of the channels are not PPT and (anti-) degradability does not hold in general. However, some important quantum informational quantities are computable on these channels. Indeed, we have asymptotically sharp minimal output entropy, Holevo capacity, one-shot quantum capacity and entanglement of formation.

Yang Yu (Chongqing University, Chongqing,)

On Positive Partial Transpose Squared Conjecture

Linear maps that are both completely positive and completely copositive are often called PPT binding maps. Here PPT stands for "positive partial transposition" since the Choi matrix of such a map is positive under partial transpose. The PPT squared conjecture asks whether the composition $\phi_2 \circ \phi_1$ of two PPT maps ϕ_1 and ϕ_2 is entanglement breaking where $\phi_1, \phi_2 \in M_n(\mathbb{C}) \otimes M_n(\mathbb{C})$. We shall talk about our proof of PPT squared conjecture in the case n=3. Another proof is claimed by Alexzander Muller Hermes from University of Copenhagen independently. The validity of PPT squared conjecture in the case n=4 is widely believed to fail but no counterexample is given so far.

List of Participants

- **Joonwoo Bae** (KAIST)
- **Eunok Bae** (Kyung Hee Unievrsity)
- **Salman Beigi** (IPM)
- **Cedric Beny** (Hanyang University)
- **Francesco Buscemi** (Nagoya University)

- **Dong Pyo Chi** (UNIST)
- **Seungbeom Chin** (SKKU)
- **Eric Chitambar** (University of Illinois Urbana-Champaign)
- **Jaeyoon Cho** (APCTP)
- **Minjin Choi** (Kyung Hee Unievrsity)
- **Benoit Collins** (Kyoto University)

- **Nilanjana Datta** (University of Cambridge)
- **Arijit Dutta** (KIAS)

- **Sergey Filippov** (Steklov Mathematical Institute of Russian Academy of Sciences)
- **Motohisa Fukuda** (Yamagata University)

- **Gilad Gour** (University of Calgary)
- **Otfried Gühne** (University Siegen Germany)
- **Seung Hyun Gwak** (Seoul National University)

- **Kyung Hoon Han** (Suwon University)
- **Sang Geun Han** (KAIST)
- **Masahito Hayashi** (Nagoya University)
- **Teiko Heinosaari** (University of Turku)
- **Jaeseong Heo** (Hanyang University)
- **Fumio Hiai** (Tohoku University)
- **Joonsuk Huh** (SKKU)

- **Gi Hyun Jang** (Ulsan University)
- **Ja A Jeong** (Seoul National University)
- **Kabgyun Jeong** (Seoul National University)
- **Kyung Chul Jeong** (ETRI)
- **Namho Jeong** (Seoul National University)
- **Sewan Ji** (ETRI)

- **Spiros Kechrimparis** (KAIST)
- **Young Hoon Kiem** (Seoul National University)
- **Hojoon Kim** (Kyung Hee University)
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- **Seung-Hyeok Kye** (Seoul National University)

- **Ludovico Lami** (University of Nottingham)
- **Hun Hee Lee** (Seoul National University)
- **Jaehak Lee** (KIAS)
- **Soojoon Lee** (Kyung Hee Unievrsity)
- **Yonghae Lee** (Kyung Hee Unievrsity)
- **Yun Jung Lee** (Hanyang University)
- **Chi-Kwong Li** (College of William and Mary)
- **Yong Been Lim** (Hanyang University)
- **Youngrong Lim** (KIAS)

- **Marcin Marciniak** (University of Gdansk)
- **Daniel McNulty** (Aberystwyth University)
- **James A Mingo** (Queen’s University)
- **Milan Mosonyi** (Budapest University of Technology and economics)

- **Min Namkung** (Hanyang University)
- **Ion Nechita** (Laboratoire de Physique Theorique, Toulouse)
- **Hui Khoon Ng** (Yale-NUS College)

- **Hiroyuki Osaka** (Ritsumeikan University)

- **Gi Hyun Park** (Hanshin University)
- **Sangjun Park** (Seoul National University)
- **Łukasz Pawela** (Polish Academy of Sciences)
- **Yiu-Tung Poon** (Iowa State University)

- **Ashutosh Rai** (KAIST)
- **Junghee Ryu** (National University of Singapore)

- **Frederic Shultz** (Wellesley College)
- **Tanmay Singal** (Hanyang University)
- **Fang Song** (Texas A&M University)
- **Szilard Szalay** (Hungarian Academy of Sciences)
- **Raymond Sze** (Hong Kong Polytechnic University)

- **Marco Tomamichel** (University of Technology Sydney)

- **Mark M. Wilde** (Louisiana State University)

- **Sang-gyun Youn** (Queen’s University)
- **Yang Yu** (Chongqing University)
- **Jiyoung Yun**