What kind of measurement statistics is preserved by a unital quantum channel?

H. F. Chau
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Abstract
Quantum systems in many noisy environments can be modeled as an ideal quantum system passing through a unital quantum channel. Therefore, it is instructive to see what kind of measurement statistics is preserved as an unknown quantum state passes through a unital quantum channel before the measurement. Here we completely characterize the kind of positive operator-valued measurement statistics that are preserved by a unital channel provided that the input quantum state to the channel is finite-dimensional. This result is a direct consequence of recently discovered structural characterization theorem of unital channels acting on finite-dimensional density matrices by our group. [1]

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[1] K. Y. Lee, C.-H. F. Fung and H. F. Chau, "Structural Characterization And Condition For Measurement Statistics Preservation Of A Unital Quantum Operation", arXiv:1112.1137.

Co-authors C.-H. F. Fung and K. Y. Lee (University of Hong Kong)

Quantum key distribution with delayed privacy amplification and its application to security proof of a two-way deterministic protocol

Chi-Hang Fred Fung
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Abstract
Privacy amplification (PA) is an essential post-processing step in quantum key distribution (QKD) for removing any information an eavesdropper may have on the final secret key. In this paper, we consider delaying PA of the final key after its use in one-time pad encryption and prove its security. We prove that the security and the key generation rate is not affected by delaying PA. Delaying PA has two applications: it serves as a tool for significantly simplifying the security proof of QKD with a two-way quantum channel, and also it is useful in QKD networks with trusted relays. To illustrate the power of the delayed PA idea, we use it to prove the security of a qubit-based two-way deterministic QKD protocol which uses four states and four encoding operations.

Co-authors Xiongfeng Ma (University of Toronto), H. F. Chau (University of Hong Kong), and Qing-yu Cai (Chinese Academy of Sciences)

Detecting quantum correlations by means of local noncommutativity

Yu Guo
Taiyuan University of Technology

Abstract
Quantum correlation is the key to our understanding of quantum physics, and, in particular, it is essential for the powerful applications of quantum information and quantum computation. There exist quantum correlations beyond entanglement, such as quantum discord (QD) and measurement-induced nonlocality (MiN) [Phys. Rev. Lett. **106**, 120401(2011)]. In [Phys. Rev. A **77**, 022113(2008)], a subclass of PPT states, called strong positive partial transposition (SPPT) state was introduced and it was conjectured there that SPPT states are separable. However, it was illustrated with examples in [Phys. Rev. A **81**, 064101(2010)] that this conjecture is not true. Viewing the origin SPPT as SPPT up to part B, in this letter, we define SPPT state up to part A and B respectively and present a separable class of SPPT states, we call super SPPT (SSPPT) states, in terms of local commutativity. In addition, classical-quantum states (which have zero QD) and nullity of MiN are characterized via local commutativity. Consequently, we highlight the relation among MiN, QD, SSPPT and separability through a unified approach for both finite- and infinite-dimensional systems: zero MiN implies zero QD, zero QD signals SSPPT and SSPPT guarantees separability, but the inverse is not.

Co-author Jinchuan Hou (Taiyuan University of Technology)

Recursive canonical construction of N-qubit spin eigenstates

Utkan Güngördü
Kinki University

Abstract
A brief review of angular momentum in quantum mechanics, use of symmetric group in particle physics, and Schur-Weyl duality will be given. A recursive scheme for obtaining canonical spin eigenstates of n-qubit systems will be introduced.

Co-authors Chi-Kwong Li (College of William & Mary), Mikio Nakahara (Kinki University), Yiu-Tung Poon (Iowa State University), and Nung-Sing Sze (The Hong Kong Polytechnic University).

Preserver problems and quantum information science

Chi-Kwong Li
College of William and Mary & The University of Hong Kong

Abstract
We will describe some recent results on preserver problems related to quantum information science including the preservers of decomposable states, product numerical ranges, higher rank numerical ranges, convex structure of states, etc. Open problems will be mentioned.

Increasing entanglement by separable operations and new monotones for W-type entanglement

Hoi-Kwong Lo
University of Toronto

Abstract
Quantum entanglement can be defined as the correlations shared between different systems that are not producible by local quantum operations and classical communication (LOCC). Owing to the complex structure of LOCC, a more general class of operations known as separable operations (SEP) is often employed to approximate LOCC, but the exact difference between LOCC and SEP remains a challenging open problem. Here, we compare the two classes in performing particular tripartite to bipartite entanglement conversions of three qubit systems. In terms of transformation success probability, we report a gap as large as 12.5 percents between SEP and LOCC. Additionally, we are able to show that the set of LOCC operations, considered as a subset of the most general quantum measurements, is not closed.
Our preprint is available at http://arxiv.org/abs/1106.1208. Our work has been selected as a plenary talk at the QIP 2012 conference in Montreal.

Co-authors Eric Chitambar and Wei Cui (University of Toronto)

Composite gates: Realization of a high quality gate out of low quality gates

Mikio Nakahara
Kinki University

Abstract
Since a quantum gate is an analogue gate, it always suffers from various types of errors. Suppose the error is systematic, that is, it is deterministic and a function of control parameters in the Hamiltonian. This happens when the calibration of a quantum computer is not good enough, for example. In this case, one can still suppress the errors by combining gates which suffer from errors: Poison quells poison! The resulting gate is known as a composite gate. We introduce mathematical background of the composite gate based on perturbation theory and give an example from our recent work. Interpretation of a composite gate as a holonomy is also outlined if time permits.

Co-authors A part of my talk is based on collaborations with Tsubasa Ichikawa, Masamitsu Bando, and Yasushi Kondo (Kinki University)

Quantum error correction without measurement and an efficient recovery operation

Yiu-Tung Poon
Iowa State University

Abstract
It is known that one can do quantum error correction without syndrome measurement, which is often done in operator quantum error correction (OQEC). However, the physical realization could be challenging, especially when the recovery process involves high-rank projection operators and a super operator. We use operator theory to improve OQEC so that the implementation can always be done by unitary gates followed by a partial trace operation. Examples are given to show that our error correction scheme outperforms the existing ones in various scenarios.

Co-authors Chi-Kwong Li (College of William & Mary), Mikio Nakahara (Kinki University), Nung-Sing Sze (The Hong Kong Polytechnic University), and Hiroyuki Tomita (Kinki University)

A characterization of optimal entanglement witnesses

Xiaofei Qi
Shanxi University

Abstract
In this paper, we present a characterization of optimal entanglement witnesses in terms of positive maps and then provide a general method of checking optimality of entanglement witnesses. Applying it, we obtain new indecomposable optimal witnesses which have no spanning property. These also provide new examples which support a recent conjecture saying that the so-called structural physical approximations to optimal positive maps (optimal entanglement witnesses) give entanglement breaking maps (separable states).

Co-author Jinchuan Hou (Taiyuan University of Technology)

Studies of Lewis-Riesenfeld invariants:
Towards a new quantum computing scheme

Yidun Wan
Kinki University

Abstract
We study Lewis-Riesenfeld invariants and their applications to the Quantum Control of two-level systems. We show that the control method based on Lewis-Riesenfeld invariants offers shortcuts to conventional adiabatic control methods. We then extend our investigation to N-level quantum systems with an emphasis on two-qubit systems. Results of the study may lead to a new scheme of quantum computation based on Lewis-Riesenfeld invariants.

Nonclassical correlations in quantum states beyond entanglement

Shengjun Wu
University of Science and Technology of China

Abstract
Much attention has been focused recently on quantifying nonclassical correlations in quantum states, this topic is very important in quantum information theory as it is the essence of quantum computation and many important quantum communication protocols. However, this is also a very tough topic as calculations related to nonclassical correlations are not easy. My talk shall be focused on recent development on quantifying nonclassical correlations beyond entanglement, especially our work on a new quantity that is similar to but more intuitive than quantum discord.

Quantum Feedback Networks and Control

Guofeng Zhang
The Hong Kong Polytechnic University

Abstract
Gaussian distributions play a fundamental role in classical (non-quantum) linear systems theory, and the fact that Gaussian distributions are preserved through the dynamics of linear systems underlies many well-known and fundamental results including LQG control and Kalman filtering. In linear quantum optics, coherent states and squeezed states are examples of quantum Gaussian states. These states are also preserved by the linear quantum dynamics, and there are many parallels with classical Gaussian states and linear systems. However, quantum states have unique features not shared by classical distributions, and it is the exploitation of such features that hold promise for new quantum technologies. In this paper we present several results that illustrate the potential for linear systems methods for processing highly non-classical quantum states. Specifically, we characterize the class of states (which we call pulsed-Gaussian states) that result when multichannel photons are input to a quantum linear system. We show that this class of quantum states is preserved by quantum linear systems. Multichannel pulsed-Gaussian states are defined via the action of certain creation and annihilation operators on Gaussian states. The Gaussian part of this specification is needed to allow for quantum linear systems with active elements, such as degenerate parametric amplifiers.
