Quantum correlations and convex geometry

Chiara Meroni

1. Abstract

Alice and Bob run an experiment: they receive a photon from a source, which can be measured in two ways; the measurement has two possible outcomes. The correlation between these outcomes is captured by the correlation body. This fundamental object in Quantum Physics is a convex body which plays an important role in understanding correlations that cannot be explained in the classical setting. We investigate the properties of the correlation body in four dimensions in detail. This is a joint work with T.P. Le, B. Sturmfels, R.F. Werner, and T. Ziegler.

Ergodic Quantum Processes in Finite von Neumann algebras

Eric Roon

1. Abstract

In 1997, H. Hennion used a non-standard metric to show a kind of multiplicative ergodic theorem for the convergence of an infinite product of positive random matrices. Recently Movassagh and Schenker proved a quantum-channel version of Hennion's ergodic theorem. We will discuss broadly the necessary conditions for a multiplicative Ergodic theorem for identically distributed quantum channels and applications to locally normal states on the spin chain. This is part of work in progress in collaboration with Brent Nelson.

Entropy Constraints for Ground Energy Optimization

Samuel Scalet

1. Abstract

We study the use of von Neumann entropy constraints for obtaining lower bounds on the ground energy of quantum many-body systems. Known methods for obtaining certificates on the ground energy typically use consistency of local observables and are expressed as semidefinite programming relaxations. The local marginals defined by such a relaxation do not necessarily satisfy entropy inequalities that follow from the existence of a global state. Here, we propose to add such entropy constraints that lead to tighter convex relaxations for the ground energy problem. We give analytical and numerical results illustrating the advantages of such entropy constraints. We also show limitations of the entropy constraints we construct: they are implied by doubling the number of sites in the relaxation and as a result they can at best lead to a quadratic improvement in terms of the matrix sizes of the variables. We explain the relation to a method for approximating the free energy known as the Markov Entropy Decomposition method.

An operator-algebraic formulation of self-testing

Yuming Zhao

1. Abstract

Suppose we have a physical system consisting of two separate labs, each capable of making a number of different measurements. If the two labs are entangled, then the measurement outcomes can be correlated in surprising ways. In quantum mechanics, we model physical systems like this with a state vector and measurement operators. However, we do not directly see the state vector and measurement operators, only the resulting measurement statistics (which are referred to as a ""correlation""). There are typically many different models achieving a given correlation. Hence it is a remarkable fact that some correlations have a unique quantum model. A correlation with this property is called a self-test. In this talk, I'll introduce the standard definition of self-testing, discuss its achievements as well as limitations, and propose an operator algebraic formulation of self-testing in terms of states on C*-algebras. This new formulation captures the standard one and extends naturally to commuting operator models. I'll also discuss some related problems in operator algebras.

Based on arXiv:2301.11291, joint work with Connor Paddock, William Slofstra, and Yangchen Zhou.

Discreteness of asymptotic tensor ranks

Jeroen Zuiddam

1. Abstract

Tensor parameters that are amortized or regularized over large tensor powers, often called "asymptotic" tensor parameters, play a central role in several areas including algebraic complexity theory (constructing fast matrix multiplication algorithms), quantum information (entanglement cost and distillable entanglement), and additive combinatorics (bounds on cap sets, sunflower-free sets, etc.). Examples are the asymptotic tensor rank, asymptotic slice rank and asymptotic subrank. Recent works (Costa-Dalai, Blatter-Draisma-Rupniewski, Christandl-Gesmundo-Zuiddam) have investigated notions of discreteness (no accumulation points) or "gaps" in the values of such tensor parameters.

We prove a general discreteness theorem for asymptotic tensor parameters of order-three tensors and use this to prove that (1) over any finite field, the asymptotic subrank and the asymptotic slice rank have no accumulation points, and (2) over the complex numbers, the asymptotic slice rank has no accumulation points.

Central to our approach are two new general lower bounds on the asymptotic subrank of tensors, which measures how much a tensor can be diagonalized. The first lower bound says that the asymptotic subrank of any concise three-tensor is at least the cube-root of the smallest dimension. The second lower bound says that any three-tensor that is "narrow enough" (has one dimension much smaller than the other two) has maximal asymptotic subrank.

Our proofs rely on new lower bounds on the maximum rank in matrix subspaces that are

obtained by slicing a three-tensor in the three different directions. We prove that for any concise tensor the product of any two such maximum ranks must be large, and as a consequence there are always two distinct directions with large max-rank.

This is joint work with Jop Briët, Matthias Christandl, Itai Leigh, and Amir Shpilka

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