The multiple facets of quantum cloning

Tuesday, July 11, 2023 - Thursday, July 13, 2023

IMT

Scientific Program

Venue: conference room, building 3R4 (FERMI)
Program
July 11

16h00 - 18h30 : **Asymmetric cloning in quantum information theory** - *PhD thesis defense*

This thesis studies quantum cloning and related quantum entanglement problems using fundamental concepts of representation theory, in particular those associated with the symmetric group. The research explores Schur-Weyl duality and its extensions, which allow efficient representation and manipulation of quantum systems, providing a valuable tool for quantum information theory. A main application of Schur-Weyl duality is the quantum cloning problem, which is studied both for cases $1 \to 2$ and for the more general cases $1 \to N$, providing new insights into the constraints imposed by the no-cloning theorem. The study is then extended to a more general quantum entanglement problem on a complete graph. The thesis is organised into chapters on Schur-Weyl duality, the mathematical foundations of quantum mechanics, quantum cloning problems and quantum entanglement problems, with an appendix providing an overview of representation theory.
July 12

11h00 - 12h00 : **Quantum expanders - Random constructions & Applications** - *Cécilia Lancien*

The goal of the talk will be to understand what quantum expanders are, what they are useful for, and how they can be constructed. We will first recall the definition of classical expander graphs, and explain how quantum analogues of these objects can be defined. We will then show that, both classically and quantumly, random constructions typically provide examples of expanders. In the quantum case, such result is derived from a spectral analysis for random matrix models with a tensor product structure. Finally, we will present implications in terms of typical decay of correlations in 1D many-body quantum systems with local interactions.
The talk will be based on joint works with David Pérez-García (https://arxiv.org/abs/1906.11682) and Pierre Youssef (https://arxiv.org/abs/2302.07772)

14h00 - 15h00 : **Exact Entanglement in the Driven Quantum Symmetric Simple Exclusion Process (QSSEP)** - *Ludwig Hruza*

Entanglement properties of driven quantum systems can potentially differ from the equilibrium situation due to long range coherences. While the mutual information between two adjacent regions of a system in equilibrium generically scales as the area of the boundary between the regions, I will show that for the boundary driven toy model QSSEP, mutual information follows a volume law. This insight is based on a mathematical method we derived for this purpose, that allows to obtain the spectrum of any subblock of a (possibly structured) random matrix from the knowledge of its "local" free cumulant. Most of my talk I will dedicate to explaining this method. Finally I will comment on a surprising observation with a physical consequence: QSSEP entanglement properties only depend on data related to its transport properties already obtained in the classical SSEP. This leads to the question whether there is a larger universality class of diffusive mesoscopic quantum systems whose entanglement properties are already encoded into their transport properties, i.e. into essentially classical data.

15h30 - 16h30 : **Incompatibility of quantum instruments** - *Leevi Leppajarvi*

Quantum instruments describe outcome probability as well as state change induced by measurement of a quantum system. Incompatibility of two instruments, i. e. the impossibility to realize them simultaneously on a given quantum system, generalizes incompatibility of channels and incompatibility of positive operator-valued measures (POVMs). We derive implications of instrument compatibility for the induced POVMs and channels. We also study relation of instrument compatibility to the concept of non-disturbance. Finally, we prove equivalence between instrument compatibility and postprocessing of certain instruments, which we term complementary instruments. We illustrate our findings on examples of various classes of instruments.
July 13

9h30 - 10h30 : **Entanglement detection based on testers** - *Maria Jivulescu*

In my talk I will review the class of SSC criteria from the point of view of entanglement testers introduced in. This approach gives rise to the opportunity to established, in a analytical way, different relations between the existing entanglement criteria and to ask new questions about others criteria that do not fit in the setting, such as enhanced CCRN criteria.

11h00 - 12h00 : **Programmability of covariant quantum channels** - *Andreas Bluhm*

A programmable quantum processor uses the states of a program register to specify one element of a set of quantum channels which is applied to an input register. It is well-known that such a device is impossible with a finite-dimensional program register for any set that contains infinitely many unitary quantum channels (No-Programming Theorem). The situation changes if the system has symmetries. In this talk, we consider channels covariant with respect to an irreducible representation of a compact group. We will see that this case can be implemented exactly by a programmable quantum processor with finite program dimension via teleportation simulation. Moreover, we show that the resulting program register has minimum Hilbert space dimension. Furthermore, we will discuss upper and lower bounds on the program register dimension of a processor implementing all group-covariant channels approximately.