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Computational Mathematics Seminar Series

Semidefinite Optimization for Quantum Information Processing

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Abstract:

In this talk, I will show how to apply semidefinite optimization to study two basic lines of quantum information processing: entanglement manipulation and communication over quantum channels. Novel mathematical tools improve our understanding of the structure of quantum entanglement and the limits of information processing with quantum systems. In the first part, I will discuss the fundamental features of quantum entanglement and develop quantitative approaches to better exploit the power of entanglement. I will introduce a computable and additive entanglement measure to quantify the amount of entanglement, which also plays an important role as the improved semidefinite programming (SDP) upper bound of distillable entanglement. Notably, I will demonstrate the irreversibility of asymptotic entanglement manipulation under positive-partial-transpose-preserving quantum operations, resolving a long-standing open problem in quantum information. In the second part, I will develop a framework of semidefinite programs to evaluate the classical and quantum communication capabilities of quantum channels in both the non-asymptotic and asymptotic regimes, which can be applied as benchmarks for near-term quantum codes. In particular, I will discuss the first general SDP strong converse bound on the classical capacity of an arbitrary quantum channel and give in particular the best known upper bound on the classical capacity of the amplitude damping channel. I will further establish a finite resource analysis of classical communication over basic channels such as the quantum erasure channel.

Speaker's Bio:
Xin Wang is a QuICS Hartree Postdoctoral Fellow in quantum information and computer science. His research aims to understand the power and limits of information processing with quantum systems. He has broad research interests including quantum Shannon theory, quantum resource theory, zero-error information theory, quantum computing, and quantum networks.

He studies the capabilities of communication over quantum channels, the structure of quantum entanglement, and the quantum resource theories with applications in quantum information processing. He is also interested in the connections of quantum computation and information to optimization, Markov chains, thermodynamics, and learning theory.

Wang received his doctorate in quantum information from the University of Technology Sydney in 2018, under the supervision of Prof. Runyao Duan and Prof. Andreas Winter.