Department of Mathematics Colloquium

Mathematics of Quantum Computational Advantage

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Abstract: Understanding the origins of quantum computational advantage is a fundamental challenge in theoretical quantum computing. One direct approach to this problem is through classical simulation algorithms. A celebrated result by Gottesman and Knill shows that quantum circuits built in the algebraic sub-theory of quantum mechanics, the stabilizer theory, can be efficiently simulated on a classical computer. This theorem can be extended to broader classes of quantum circuits by employing sampling algorithms based on operator-theoretic polytopes. A natural framework for studying these simulation polytopes and other foundational constructs in quantum theory is the theory of simplicial distributions that extends the former sheaf-theoretic approach of Abramsky and Brandenburger. Foundational notions, such as Bell's non-locality and its generalization quantum contextuality, can be interpreted as topological phenomena in this setting. Moreover, Bell inequalities and extremal contextual distributions, useful for quantum information processing, can be analyzed using simplicial methods from algebraic topology. In this talk, I will present this diverse landscape, highlighting the intricate connections among algebraic topology, polyhedral combinatorics, and group theory in understanding quantum computational advantage.

Date: Wednesday, March 7, 2025

Time: 15:40-16:40

Place: Mathematics Seminar Room, SA-141

Light refreshments will be served prior to the seminar.