THE UNIVERSITY OF HONG KONG

Institute of Mathematical Research
Department of Mathematics

Seminar

Lie Algebraic Analysis of Variational Quantum Algorithms

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Abstract

Variational quantum algorithms (VQAs) leverage classical optimization to train parameters in parameterized quantum circuits, offering a promising approach for both near-term quantum computing and future quantum AI. However, their practical implementation faces key challenges, including gradient estimation, barren plateaus, hardware and sampling noise, and circuit structure design.

This talk introduces a Lie algebraic framework for analyzing VQAs. We investigate the algebraic structure of the Quantum Approximate Optimization Algorithm (QAOA) for combinatorial optimization on special graph classes. Specifically, we derive the dimension and explicit basis of the associated Lie algebras, characterize their centers, and provide decompositions into simple Lie subalgebras with explicit bases. Our analysis reveals that QAOA on cycle graphs avoids the barren plateau problem—a common training obstacle in VQAs. Additionally, we introduce methods for efficiently constructing large Lie algebras from smaller ones. These results establish a foundation for rigorous algebraic analysis of VQAs and suggest new strategies for algorithm design. We hope this work inspires further systematic research at the intersection of quantum computing and Lie theory.

Date:	June 27, 2025 (Friday)
Time:	10:30 – 11:30am
Venue:	Room 101, KK Leung Building, HKU

All are welcome