上海数学与交叉学科研究院

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SIMIS Seminar series on Quantum computing, Quantum simulation and Strongly-correlated systems

Prof. Huangjun Zhu

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"The Magic in Shadow Estimation Based on the Clifford Group"

Abstract

Shadow estimation is a sample-efficient protocol for learning the properties of a quantum system using randomized measurements, but the current understanding on qudit shadow estimation is quite limited compared with the qubit setting. Here we clarify the sample complexity of qudit shadow estimation based on the Clifford group, where the local dimension d is an odd prime. Notably, we show that the overhead of qudit shadow estimation over the qubit counterpart is only $O(d)$, which is independent of the qudit number n, although the set of stabilizer states may deviate exponentially from a 3-design with respect to the third moment operator. Furthermore, by adding one layer of magic gates, we propose a simple circuit that can significantly boost the efficiency. Actually, a single magic gate can already eliminate the $O(d)$ overhead in qudit shadow estimation and bridge the gap from the qubit setting. In addition, in thrifty shadow estimation based on the Clifford group, the variance is inversely correlated with the degree of nonstabilizerness, which is a key resource in quantum information processing. For fidelity estimation, it decreases exponentially with the stabilizer 2-Rényi entropy of the target state, which endows the stabilizer 2-Rényi entropy with a clear operational meaning.

References

[1] C. Mao, C. Yi, and H. Zhu, Qudit Shadow Estimation Based on the Clifford Group and the Power of a Single Magic Gate, Phys. Rev. Lett. 134, 160801 (2025).
[2] H. Zhu, C. Mao, and C. Yi, Third moments of qudit Clifford orbits and 3-designs based on magic orbits, arXiv:2410.13575.
[3] D. Chen and H. Zhu, Nonstabilizerness Enhances Thrifty Shadow Estimation, arXiv: 2410.23977.

Biography of the speaker

Prof. Huangjun Zhu got Bachelor, Master, and PhD degrees from Zhejiang University, Peking University, and National University of Singapore, respectively. After postdoctoral research at Perimeter Institute and Cologne Institute for Theoretical Physics, he joined Department of physics, Fudan University in January 2018. His main research interest is quantum information theory, including quantum measurements, quantum characterization, verification, and validation (QCVV), entanglement theory, and blind quantum computation etc.

Date and Place: May 19th, Monday, 2025, 14:00h-15:00h. Room: 1310. Send comments or questions to: Miguel Tierz (Seminar organizer) to tierz at simis.cn