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

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"Hybrid Shadow Estimation: Theory and Experiment"

Abstract

Estimating nonlinear functions of quantum states, such as the moment and entanglement, is of fundamental and practical interest in quantum science and technology. In this talk, I would introduce our recent theoretical proposal and its experimental demonstration on this topic. The theoretical work [1] introduces the hybrid shadow (HS) estimation framework for measuring general nonlinear functions, which combines swap test and randomized measurements. Such hybrid framework utilizes the partial coherent power of the intermediate-scale quantum processor and dramatically reduces measurement and postprocessing costs. We analytically and numerically demonstrate the advantage of this framework in tasks of state-moment estimation and quantum error mitigation. In the collaborative experimental work [2], we implement HS in an optical system via designing and realizing a deterministic quantum Fredkin gate over multiple degrees of freedom of a single photon. We demonstrate HS in the estimations of higher-order functions and further apply it in a proof-of-principle quantum metrology experiment, where the accuracy of parameter estimation is enhanced with the assistance of virtual distillation. Our results suggest that HS is an efficient and powerful tool for shadow-estimation-enabled quantum information processing.

References

[1] A hybrid framework for estimating nonlinear functions of quantum states, Y Zhou, Z Liu, npj Quantum Information 10 (1), 62(2024)

[2] Experimental Hybrid Shadow Tomography and Distillation, XJ Peng, Q Liu, L Liu, T Zhang, Y Zhou, H Lu, Physical Review Applied 23 (1), 014075 (2025)

Biography of the speaker

You Zhou is an assistant prof. at the School of Information Science and Engineering, Fudan University, and the Key Laboratory of Electromagnetic Wave Information Science, Ministry of Education. His research focuses on the fundamental theory of quantum information and computation. He received his Bachelor's degree from Zhejiang University in 2014, and his Ph.D. Tsinghua University in 2019. He has conducted research as a visiting scholar and postdoctoral fellow at the University of Science and Technology of China, Harvard University, and Nanyang Technological University. His research interests include quantum entanglement and correlations, quantum system benchmarking and error suppression, and quantum simulation algorithms. He has published 29 academic papers in journals such as PRL, npj Quantum Information, and Quantum, of which 21 are (co-)first or corresponding author publications.

Date and Place: March 26th, Wednesday, 2025, 14:00h-15:00h. Room: 1210. Send comments or questions to: Miguel Tierz (Seminar organizer) to tierz at simis.cn