中央研究院 資訊科學研究所
Institute of Information Science, Academia Sinica

What cannot be learned in the quantum universe

Dr. Hsin-Yuan Huang

Assistant Professor of Theoretical Physics, Caltech (USA)
William H. Hurt Scholar
Staff Research Scientist, Google Quantum AI (USA)

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Abstract

Recent advances have enhanced our understanding of what can be efficiently learned in the quantum universe. However, certain fundamental aspects remain resistant to efficient learning using known algorithms. This talk explores several fundamental properties, including time, causal structure, topological order, noise, and demonstrates how they can be provably hard to learn. These results stem from our work on how to construct random unitaries (with Fermi Ma, STOC 2025) and generate them in extremely low depth (with Thomas Schuster and Jonas Haferkamp, Science 2025). Examining these unlearnable aspects of our world sheds light on the fundamental limits of scientific inquiry in the quantum realm.

Biography

Hsin-Yuan Huang (Robert) is an Assistant Professor of Theoretical Physics at Caltech and a Senior Research Scientist at Google Quantum AI. He completed his Ph.D. at Caltech under John Preskill and Thomas Vidick. His research leverages learning theory to advance quantum computation, physics, and information science, with contributions including classical shadow tomography, machine learning algorithms for quantum many-body problems, and quantum advantages in learning from experiments. His work has appeared in premier venues including Nature, Science, FOCS, and STOC, and has delivered over 160 invited talks. His doctoral thesis "Learning in the Quantum Universe" earned the Milton and Francis Clauser Doctoral Prize for the most original research among all 2024 Caltech graduates, and he holds additional honors including the Google Ph.D. Fellowship, Boeing Quantum Creator Prize, and the William H. Hurt Scholar endowed professorship.

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