

S E M I N A R

Divide-and-Conquer Simulation of Open Quantum Systems

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Venues: Online and Physics Seminar Room, Stellenbosch University

ABSTRACT

One of the promises of quantum computing is to simulate physical systems efficiently. However, the simulation of open quantum systems - where interactions with the environment play a crucial role - remains challenging for quantum computing, as it is impossible to implement deterministically non-unitary operators on a quantum computer without auxiliary qubits. The Stinespring dilation can simulate an open dynamic but requires a high circuit depth, which is impractical for NISQ devices. An alternative approach is parallel probabilistic block-encoding methods, such as the Sz.-Nagy and Singular Value Decomposition dilations. These methods result in shallower circuits but are hybrid methods, and we do not simulate the quantum dynamic on the quantum computer. In this work, we describe a divide-and-conquer strategy for preparing mixed states to combine the output of each Kraus operator dilation and obtain the complete dynamic on quantum hardware with a lower circuit depth. The work also introduces a balanced strategy that groups the original Kraus operators into an expanded operator, leading to a trade-off between circuit depth, CNOT count, and number of qubits. We perform a computational analysis to demonstrate the advantages of the new method and present a proof-of-concept simulation of the Fenna-Matthews-Olson dynamic on current quantum hardware.



BIOGRAPHY

Nadja Kolb Bernardes is a Professor of Physics at the Federal University of Pernambuco (Recife, Brazil), with research focusing on quantum information theory, particularly open quantum systems and non-Markovian dynamics. Nadja holds a PhD in Physics from the Max Planck Institute for the Science of Light (Erlangen, Germany 2012), where she researched long-distance quantum communication. She is on the board of the Brazilian Physical Society and a researcher at the National Institute of Quantum Information Science and Technology.

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