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FROM QUANTUM OPEN SYSTEMS TO QUANTUM COMPUTING

ALBERTO ACEVEDO[*], ANTONIO FALCÓ[*]
AND MIGUEL ÁNGEL GARCÍA MARCH[†]

[*] Departamento de Matemáticas, Física y Ciencias Tecnológicas
Universidad CEU Cardenal Herrera
San Bartolomé 55, Alfara del Patriarca 46115, Valencia (Spain)
alberto.acevedomelendez,afalco@uchceu.es

[†] IUMPA - Instituto Universitario de Matemática Pura y Aplicada
Universitat Politècnica de València
Camí de Vera S/N 46022 València (Spain)
garciamarch@upv.es

ABSTRACT

The theoretical frameworks of Open Quantum, describing how quantum systems interact with their environment, are essential in understanding and advancing quantum computing. Quantum computing processes rely on the preservation of quantum coherence, crucial for the reliable processing of information. However, real-world quantum systems are never isolated; they are open to interactions with their surroundings, leading to decoherence and noise, which degrade the performance of quantum algorithms beyond viavility after an amount of time dependant on the decoherence time-scale which in turn depends on the architecture of the quantum computer. For instance, in quantum computers based on superconducting qubits, environmental factors such as stray electromagnetic radiation can rapidly cause qubits to lose coherence.

The aim of this session is to provide a formal approximation to some open problems in this field as (a) Designing Fault-Tolerant Architectures: While error correction helps mitigate decoherence, fault-tolerant quantum computing requires better architectural designs to handle noise effectively. Finding efficient codes that require fewer physical qubits remains an open problem (b) Optimal Control of Open Quantum Systems: Developing control techniques that can dynamically adapt to varying environmental conditions and noise in real-time is a significant challenge. These control strategies must balance the need for fast computation with the requirement of maintaining coherence over extended periods. (c) Thermodynamic Limits of Quantum Computing: An ongoing question in quantum thermodynamics is understanding the energy efficiency and heat dissipation in open quantum systems. Identifying the fundamental thermodynamic limits of quantum computers and how they interact with environmental noise remains a challenging area of research. (d) Decoherence-Free Subspaces: Another area of research is identifying and utilizing decoherence-free subspaces or subsystems, where specific quantum states are immune to certain types of environmental noise for error-resistant quantum computation.