LABORATOIRE DE PHYSIQUE ET
MODELISATION DES MILIEUX CONDENSES –UMR 5493

Master internship proposal

Topic: **Measurement of the quantum Fisher information with randomized measurements**

Group: Laboratoire de Physique et Modélisation des Milieux Condensés (LPMMC), Grenoble

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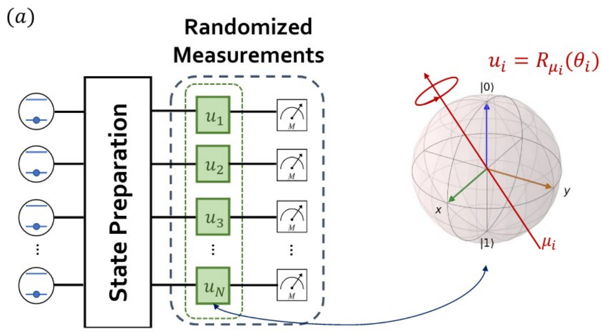
Summary

Synthetic quantum systems of Rydberg atoms, trapped ions, superconducting qubits, quantum dots, etc, have reached a new era: Programmable coherent interactions can be implemented between tens of particles, and in highly tunable geometries. These systems can be used as *quantum simulators* to understand unique features of quantum phases of condensed matter or high-energy physics [1]. Synthetic quantum systems can also implement *quantum computers*. These devices offer the prospect to outperform classical computers, in particular to solve “hard” classical optimization problems [2].

A central aspect for the future of quantum simulation and computation is the development of experimental tools to probe a new generation of many-body quantum states, *which could not be realized so far*. While standard measurement techniques give typically access to low-order correlation functions, accessing experimentally true quantum features, such as entanglement, was considered for many years as an outstanding challenge for quantum technologies. Recently, we have developed and demonstrated protocols known as *randomized measurements* (RM) [3,4,5], that have the potential to address this challenge.



The internship consists in testing experimentally a new RM protocol that gives access to the quantum Fisher information (QFI) [6]. The QFI is a central quantity to assess the performance of quantum states to measure parameters in the framework of quantum metrology. The QFI can also certify the presence of entanglement between multiple parts of a quantum system.

To implement the protocol, we will use IBM quantum computers, and implement a quantum error mitigation algorithm [7] to protect our estimation of the QFI from errors occurring during the measurement process.

This work may be continued as a PhD.

References

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[7] S. Chen, W. Yu, P. Zeng, and S. T. Flammia, PRX Quantum **2**, 030348 (2021).