Master 2: International Centre for Fundamental Physics

INTERNSHIP PROPOSAL

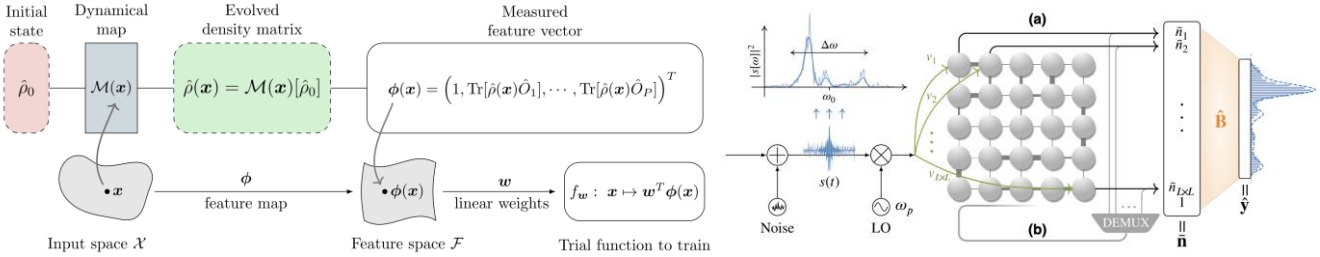
Laboratory name : Matériaux et Phénomènes Quantiques – MPQ UMR7162
Location : Université Paris Cité – 10 Rue A. Domon et L. Duquet – Bât. Condorcet – 75013 PARIS

Intership director : Prof. Cristiano Ciuti (THEORIE group)
@mail : cristiano.ciuti@u-paris.fr
https://mpq.u-paris.fr/en/annuaire/ciuti-cristiano-en/
https://scholar.google.it/citations?user=rzc1ND0AAAAJ&hl=en

Emergent quantum computation from the dynamics of complex systems

Investigating innovative approaches to analog computing by harnessing the emerging dynamics of quantum systems represents an exciting and modern frontier. This endeavor holds the potential to transform domains such as optimization, machine learning, and simulations by addressing complex problems that classical computers struggle to solve. It introduces a new computational paradigm applicable to fields like optimization, artificial intelligence, and scientific simulations, offering the promise of improving the efficiency and effectiveness of solving intricate real-world challenges.

During this theoretical internship, the Master's student will learn, generalize, and apply methods developed in recent and promising works [1-6] to explore innovative and advanced strategies for utilizing the intricacies of quantum systems. The goal is to develop emergent computational capabilities, particularly aimed at solving optimization problems and tackling interdisciplinary challenges. The internship's theoretical research will involve both analytical and numerical methods, with a focus on the quantum many-body physics of state-of-the-art quantum platforms, including superconducting quantum circuits [5,6] and other quantum systems.



[1] Z. Denis, I. Favero, C. Ciuti, *Photonic kernel machine learning for ultrafast spectral analysis*, Physical Review Applied 17, 034077 (2021).
[2] Z. Li, V. Heyraud, K. Donatella, Z. Denis, C. Ciuti, *Machine learning via relativity-inspired quantum dynamics* , Physical Review A 106, 032413 (2022).
[3] V. Heyraud, Z. Li, Z. Denis, A. Le Boité, and C. Ciuti, *Noisy quantum kernel machines*, Phys. Rev. A 106, 052421 (2022)
[4] V. Heyraud, Z. Li, K. Donatella, A. Le Boité, C. Ciuti, *Efficient estimation of trainability for variational quantum circuits*, PRX Quantum 4, 040335 (2024)
[5] N. Mehta, R. Kuzmin, C. Ciuti, V. E. Manucharyan, *Down-conversion of a single photon as a probe of many-body localization*, Nature 613, 650-655 (2023)
[6] L. Giacomelli, C. Ciuti, *Emergent quantum phase transition of a Josephson junction coupled to a high-impedance multi-mode resonator*, Nature Comm. 15, 5455 (2024)

Condensed Matter Physics : YES	**Macroscopic Physics and complexity** : YES
Quantum Physics : YES	**Theoretical Physics** : YES