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)
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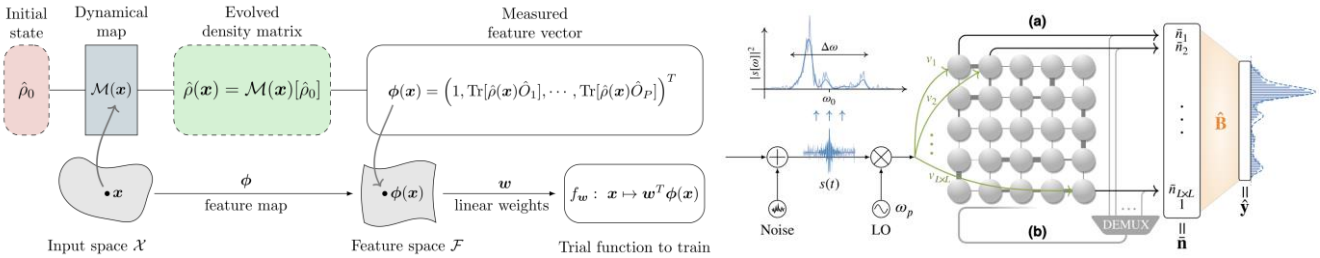
https://scholar.google.it/citations?user=rzc1ND0AAAAJ&hl=en

Emergent computation from the dynamics of complex quantum systems

Investigating innovative approaches to analog computing through harnessing the emerging dynamics of quantum systems represents an exciting and contemporary frontier. This endeavor carries the potential to transform domains like optimization, machine learning, and simulations by adeptly addressing challenging problems that classical computers struggle with. It introduces a fresh computational paradigm applicable to fields such as optimization, artificial intelligence, and scientific simulations, thereby holding the promise of enhancing the efficiency and effectiveness of solving intricate real-world problems.

During this theoretical internship, the Master student will learn, generalize and employ methods developed in recent and promising works [1-6] to delve into innovative and advanced strategies for harnessing the intricacies of quantum systems. Our goal is to develop emergent computational capabilities, particularly geared towards solving optimization problems and addressing interdisciplinary challenges. The internship's theoretical research will encompass both analytical and numerical methods, with a specific focus on quantum many-body physics of state-of-the-art quantum platforms based on 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*, arXiv:2302.04649

[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*, arXiv:2307.06383

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