Master 2: International Centre for Fundamental Physics

INTERNSHIP PROPOSAL

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

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Theory of superconducting quantum networks

Superconducting quantum circuits represent one of the most promising physical platforms for the exploration of fascinating quantum phenomena and for remarkable applications in quantum information, quantum simulation, quantum metrology and neuromorphic quantum systems.

Recent quantum circuits [1,2] based on large arrays of Josephson junctions have been shown to create artificial non-dissipative "environments" with extremely high-impedance, which, translating into the language of cavity quantum electrodynamics, are equivalent to create a very large effective fine-structure constant. This paves the way to unexplored regimes of light-matter interaction that result in strongly correlated systems and that in principle can create topologically robust effects with applications in quantum metrology.

In this internship that can be followed by a PhD thesis, the M2 student will learn state-of-the-art theoretical techniques on superconductor quantum circuits, quantum optics, theory of open quantum manybody and complex systems. The internship student will explore one of the two possible research lines: (i) quantum manybody phase transitions in high-impedance circuit QED; (ii) study of topologically robust transport for quantum metrology. As a bonus, active collaborations on these topics with experimental circuit QED groups in France and in the USA will further enrich the research activity.

[1] J. Puertas Martínez et al., *A tunable Josephson platform to explore many-body quantum optics in circuit-QED,* Nature PJ Quantum Information 5, 19 (2019).

[2] R. Kuzmin, N. Mehta, N. Grabon, R. Mencia, V. E. Manucharyan, *Superstrong coupling in circuit quantum electrodynamics,* Nature PJ Quantum Information 5, 20 (2019).

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