

Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Institut de Physique Théorique, CEA Saclay
CNRS identification code: UMR 3681
Internship director's surname: Sangouard, Nicolas
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Web page: <https://quantum.paris/>
Internship location: CEA Saclay, l'Orme des Merisiers, Bâtiment 774

Thesis possibility after internship: **YES**, already funded
Funding: **YES**
Type of funding: **CIFRE**

Distributed surface code lattice surgery

The creation of a network of medium scale quantum computing cells connected to each other by means of entanglement is establishing as one the most promising approach towards large scale quantum computing. The project aims to extend the most common error correction protocol -- the surface code with a lattice surgery construction -- to the distributed setting. The basic idea is to perform stabilizer measurements across physically separated cells by means of shared noisy entangled Bell pairs.

In this framework, the intern will have to finely understand the specificities of error correction codes and use known or develop its own simulator of noisy quantum circuits to efficiently evaluate the threshold and overhead of a distributed surface code. In parallel, the intern will investigate a large scale quantum algorithm -- like Shor's algorithm -- to estimate precisely the resource and runtime needed to run such an algorithm on a physical platform using cat qubits and driven by a distributed surface code lattice surgery.

Upon success, the intern will show the potential of surface code lattice surgery for realizing distributed quantum computing and give a precise estimate on the constraints that quantum networks must fulfill to realize large scale algorithms in a distributed way.

The intern will be supervised by N. Sangouard (CEA-Saclay), E. Gouzien and J. Guillaud (Alice&Bob). Depending on the student motivations, the internship might be followed by a PhD thesis (already funded) between the institute of theoretical physics (CEA-Saclay) and the startup company Alice&Bob (Paris).

For recent publications are relevant for the project, see
J. Guillaud, J. Cohen & M. Mirrahimi, Scipost Phys. Lect. Notes 71 (2023), arxiv :2203.03222
E. Gouzien & N. Sangouard Phys. Rev. Lett. 127, 140503 (2021) ; arXiv:2103.06159
E. Gouzien, D. Ruiz, F.-M. Le Régent, J. Guillaud & N. Sangouard, Phys. Rev. Lett. 131, 040602 (2023) ; arXiv:2302.06639

Condensed Matter Physics: **YES** Soft Matter and Biological Physics: **NO**
Quantum Physics: **YES** Theoretical Physics: **YES**