Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique, Ecole Normale Supérieure de Lyon
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Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Quantum control of superconducting circuits using neural networks

A quantum bit can encode at most one bit of information, yet it can be used to gather information about a multi-level quantum system. The most common strategy is to leverage the qubit to ask a series of yes/no questions. Using a superconducting qubit coupled to a superconducting microwave cavity, we have now pushed this strategy to its limit and can determine the binary decomposition of the number of photons contained in the cavity mode bit by bit [1]. We have also recently introduced a way to go beyond this limitation. Indeed, we now realize experiments where it is possible to ask all the questions simultaneously by frequency multiplexing the qubit measurement [2].

Going beyond that, we want to use this device as a testbed for quantum control using neural networks. A first step would be to stabilize the quantum state of the superconducting cavity based on the continuous multiplexed measurement record. Considering the number of parameters to tune and the large size of the Hilbert space, devising the required feedback protocol is quite challenging. Our plan is thus to train a neural network to learn how to perform such a feedback control. We were the first group to realize quantum feedback control with FPGA boards (the fastest reprogrammable electronic boards) [3], and we plan to harness this fantastic hardware again. For that purpose, we are collaborating with the startup Quantum Machines who will build the hardware that hosts a neural network on an FPGA board and with the group of Florian Marquardt who is a specialist of machine learning for quantum systems.

Operating a neural network on an FPGA would be a first. The project has tons of possible applications in quantum information processing and quantum sensing such as quantum error correction and adaptative measurements.

This is an experimental project and the candidate will learn about low noise microwave measurements, nanofabrication and cryogenic techniques. Beyond an obvious interest for experimental work, the candidate should be at ease with quantum information, have excellent analytical skills and a taste for programming.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

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