INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay
CNRS identification code: UMR137
Internship director: MARKOVIC Danijela
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Internship location: 1, avenue Augustin Fresnel, 91120 Palaiseau

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ERC

Training of superconducting analog quantum neural networks

Our team in Laboratoire Albert Fert has recently demonstrated that a quantum reservoir neural network implemented on a circuit QED system composed of a transmon qubit coupled to a superconducting cavity can learn to classify input classical data [1]. In this pilot experiment, neural outputs were obtained by measuring probability occupations of different Fock states of a single quantum oscillator and training was performed on a classical computer after the measurement. In order to perform harder learning tasks and increase the expressivity of the neural network, training should be done in the quantum system as well [2]. For this, we are developing new training algorithms, specific to analog quantum systems.
The goal of the internship and subsequent PhD thesis is to simulate and implement layers of parametrized operations that will be applied on the quantum systems and whose parameters will be trained using physics aware learning methods.

The work will consist in:
- Development of physics-aware learning algorithms
- Implementation of parametrized gates and measurements
- Optimization of measurement sequence and python code for training the superconducting quantum neural network
- Training the network to perform classical tasks (recognize images) and quantum tasks (recognize quantum states)

Required expertise:
- Expertise in Python
- Knowledge and basic practice of microwave measurement techniques
- Knowledge of cryogenic measurements is a plus
- Knowledge of machine learning and Pytorch is a plus.

[1] J. Dudas *et al.* Quantum reservoir computing implementation on coherently coupled quantum oscillators. *npj Quantum Inf* **9**, 64 (2023)
[2] D. Marković & J. Grollier. Quantum neuromorphic computing. *Appl. Phys. Lett.* **117**, 150501 (2020)

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