INTERNSHIP/PHD PROPOSAL IN QUANTUM TECHNOLOGY

Laboratory name: ***Laboratoire de Physique des Solides***
CNRS identification code: UMR8502
Internship director'surnames: Julien BASSET and Jérôme ESTEVE
E-mail: Julien.basset@universite-paris-saclay.fr, Jerome.esteve@ universite-paris-saclay.fr
Phone numbers: 0033169158011, 0033169155365
Web page: https://equipes2.lps.u-psud.fr/ns2/

Internship location: Laboratoire de Physique des Solides - Université Paris Saclay- Groupe NS2 – 1 rue Nicolas Appert 91405 Orsay

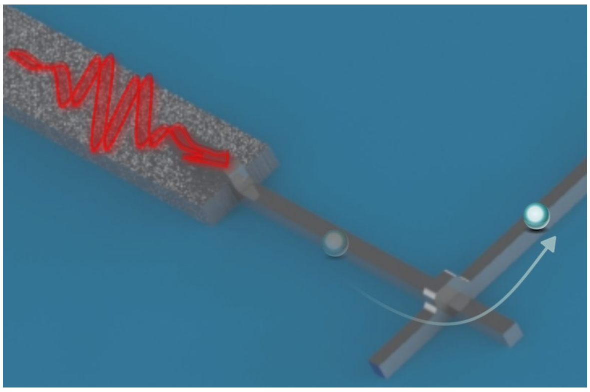
Thesis possibility after internship: YES
Funding: YES/NO If YES, which type of funding: Ecole doctorale/Quantum saclay

Superconducting quantum bit readout with a single microwave photon-to-electron detector

Subject :

With the advent of circuit quantum electro-dynamics, the most advanced platform to realize fully controllable and scalable quantum processors using superconducting quantum bits, the vector of information and measurement protocols have become microwave photons in the [4-8]~GHz band. Developing an efficient and fast single microwave photon detector thus holds immense promise in advancing quantum computing, communication and sensing.

Historically, the technology used by optical photon detection is based on semiconductor materials whose gap appropriately matches the frequency domain of interest. Transferring this technology to microwave photons fails due to the natural mismatch between semiconducting gap and microwave frequency photons which carry about 10^5 times less energy than an optical visible one.



Artistic view of the ideal photoelectric effect demonstrated in reference [2].

We have recently overcome this problem by realizing a ***microwave photon to electron converter*** in which a superconducting tunnel junction acts as a voltage tuneable quantum absorber through the photon-assisted tunneling of quasiparticles [1,2]. We further developped a method to detect the single charge associated to the absorption of the photon making it a ***good single microwave photon detector [3].***

We are now seeking an enthusiastic student to employ this detector in ***implementing an innovative measurement protocol aimed at characterizing superconducting qubits***. In this project, the student will work closely with at least 2 permanent researchers. The first goal will be to develop a hybrid sample using superconducting circuits made out of granular aluminum, a disordered superconductor necessary for microwave detection, on one hand and a superconducting qubit on the other hand. Everything will be realized in a ***nanofabrication clean room*** by electron beam lithography and metal evaporation. Measurements will then be carried in a new ***dilution refrigerator with base temperature of 20mK and high precision electronics***.

Beyond advancing fundamental knowledge, this work opens ***pathways to applications in quantum computing and sensing***, offering the student a unique opportunity to build expertise that is highly sought after for a ***career as a quantum scientist***.

[1] Aiello et al, *Quantum bath engineering of a high impedance microwave mode through quasiparticle tunnelling,* Nature Communications 13, 7146 (2022). https://www.iledefrance-gif.cnrs.fr/fr/cnrsinfo/de-leffet-photoelectrique-aux-technologies-quantiques

[2] Stanisavljevic et al, *Efficient Microwave Photon-to-Electron Conversion in a High-Impedance Quantum Circuit*, Physical Review Letters **133**, 076302 (2024). https://physics.aps.org/articles/v17/127

[3] Basset et al, *Single microwave photon detection based on photoelectric effect*, in preparation (2025) + patent writing (2025).

Condensed Matter Physics:	YES	Macroscopic Physics and complexity:	NO
Quantum Physics:	YES	Theoretical Physics:	NO