Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

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

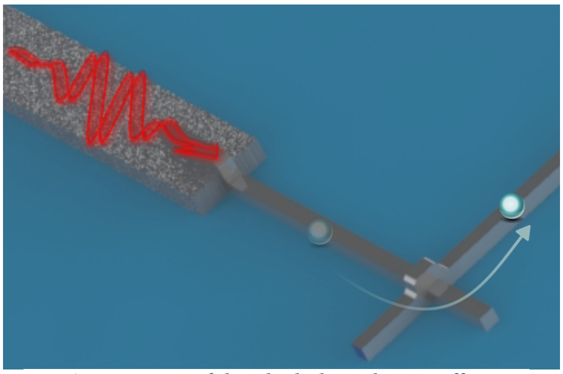
Thesis possibility after internship:	YES
Funding: YES/NO	If YES, which type of funding:

Towards photoelectric detection of single microwave photons using a super-inductance circuit

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 has 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 ***quasi-ideal 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]. The achieved quantum efficiency, estimated from the measured photo-assisted current, approaches unity [2].

We are now seeking for an enthusiastic student to work on the development of ***detection techniques to measure the single charge associated to the absorption of a single microwave photon.*** In this project, the student will work closely with 2 permanent researchers and a freshly graduated phd student. The goal will be to develop charge detection using superconducting circuits made out of granular aluminum, a disordered superconductor, 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. The student will also get involved into numerical simulations of the quantum master equation governing the dynamics of the system.

[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

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