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
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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:

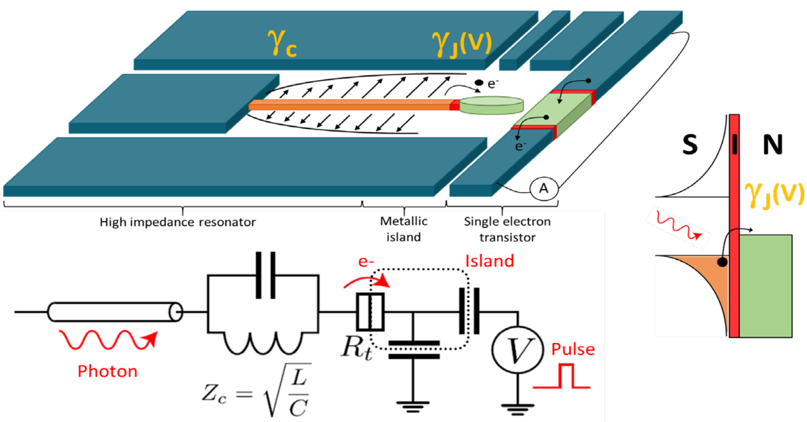
Quantum microwave detection using a super-inductance circuit

Subject : Optical photon detectors are foundational tools in various quantum technologies and applications, facilitating secure communication, precision measurements, advanced imaging, and fundamental quantum research.

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. Realizing a ***continuous photo-electron converter in the microwave domain*** is thus a naturally challenging task which has recently received attention.

Indeed, 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 microwave photo-electron converter thus holds immense promise in advancing quantum computing, communication and sensing.

In this context we have very recently realized 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]. The achieved quantum efficiency, estimated from the measured photo-assisted current, approaches unity [2]. This finding paves the way for the proposed project which aims at ***detecting single microwave photons using charge detection*** techniques using ***superinductances*** currently under development in the lab.



Detection principle (a) Detection scheme proposed to detect single microwave photons using a high impedance $\lambda/4$ resonator coupled on one side with rate γ_c and to a tunnel junction on the other side with rate $\gamma_J(V)$ (b) Simplified equivalent circuit of the detection setup. (c) Semiconducting representation of the photon-assisted electron tunneling process in a SIN junction.

The student will join the project lead by 2 permanent researchers, 1 graduating phd student and 1 post-doc. 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 brand new dilution refrigerator with base temperature of 20mK and high precision electronics.

[1] Aiello et al, Nature Communications 13, 7146 (2022) [2] Stanisavljevic et al, in preparation (2023)

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