Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Service de Physique de l'Etat Condensé, SPEC, Université Paris-Saclay, CEA-CNRS
CNRS identification code: UMR 3680
Internship director'surname: ALTIMIRAS/PORTIER/ROCHE
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Internship location: Service de Physique de l'Etat Condensé, SPEC, Bât 772 L'Orme des Merisiers, CEA-Saclay, 91190, Gif-sur-Yvette
Thesis possibility after internship: YES
Funding: YES/NO If YES, which type of funding: ANR ½ thesis

Title: Strong coupling QED of quantum conductors

Summary (half a page maximum):

Quantum transport investigates the dynamics of electrical circuits displaying a quantum mechanical behavior. This is achievable by patterning circuits in the nm/um scale in clean room environments, and cooling them at T~15 mK in dilution fridges. A remarkable aspect of such quantum dynamics is that the electrical current fluctuates, even in response to a strictly DC bias. Detecting these quantum fluctuations is highly informative as it conveys information on the granularity of charge, the statistics of the carriers but also on the characteristic transport times such as the electronic scattering time or on interaction effects.

In the last years, our lab has developed several experimental schemes and technics in order to measure efficiently such quantum fluctuations in the few GHz range. In a qualitative level, measuring at this frequency range f_{det}~6 GHz gives access to the quantum optical regime $hf_{det}>>k_BT$, where one needs to provide a quantum description not only for the electrical current flowing through the conductor, but also for the electromagnetic fields exchanged with its detection scheme. This so-called circuit quantum electrodynamics regime is appealing since the corresponding ligh-matter coupling, proportional to the detection impedance, can be engineered and take non-perturbative values unparalleled in other physical systems. In a quantitative level, using this frequency range increases the experimental window: On the one side, performing faster experiments enables probing shorter transport time scales, or equivalently larger interaction energy scales. On the other side, it naturally provides larger detection bandwidths enabling to perform higher resolution experiments tracking subtle interaction effects.

The purpose of this internship is to design, micro-fabricate and test in a cryogenic environment a new generation of radiofrequency impedance matching circuits, in order to increase notably the bandwidth of the detection window. The goal of this project is to obtain a detection bandwidth larger than the thermal bandwidth at 15 mK thus δf_{det}~1 GHz, with a detection impedance of the order to the resistance quantum R_Q=h/e^2~25.8 kΩ. Such a device would enable in a future PhD project to detect how the sub-Poissonian properties of Fermions being scattered upon a potential barrier might imprint on the properties of the resulting radiated RF field [1, 2].

[1] Beenaker & Schomerus, Phys.Rev.Lett. 93, 096801 (2004)
[2] Hassler & Otten, Phys. Rev. B 92, 195417 (2015)

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