IRAMIS : Institut Rayonnement Matière de Saclay

Saclay

SPEC/GNE

Fort couplage QED à des conducteurs quantiques

Spécialité Physique de la matière condensée

Niveau d'étude Bac+5

Formation Master 2

Unité d'accueil SPEC/GNE

Candidature avant le 30/04/2021

Durée 6 mois

Poursuite possible en thèse oui

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Résumé

Pendant ce stage nous développerons des circuits de détection microondes de haute impédance et grande bande passante à fin de réaliser des expériences d'électrodynamique quantique avec des conducteurs quantiquement coherents.

Sujet détaillé

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 fdet~6 GHz gives access to the quantum optical regime hfdet>>kBT, 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 ?fdet~1 GHz, with a detection impedance of the order to the resistance quantum RQ=h/e^2~25.8 k?. 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)

Mots clés

Transport quantique, electrodynamique quantique, radiofréquences

Compétences

Simulation de circuits microondes, nano et micro fabrication, mesures électriques en environnements cryogéniques

Logiciels

Strong coupling QED of quantum conductors

Summary

During this internship, we will develop high impedance and large bandwidth RF detection circuits in order to perform quantum electrodynamics experiments on quantum coherent electrical conductors.

Full description

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Keywords

Quantum transport, quantum electrodynamics, radiofrequencies

Skills

RF circuit simulations, nano and microfabrication techniques, electrical measurements in cryogenic environments

Softwares