Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage

Date de la proposition : 25/11/2015

Responsable du stage / *internship supervisor*:

Nom / *name*: BERTET — Prénom/ *first name* : Patrice

Tél : 01 69 08 55 29 — Fax : 01 69 08 74 42

Courriel / *mail*: Patrice.bertet@cea.fr

Nom du Laboratoire / *laboratory name*: Quantronics group

Code d'identification : — Organisme : CEA, CNRS, Université Paris-Saclay

Site Internet / *web site*: http://iramis.cea.fr/drecam/spec/Pres/Quantro/static/

Adresse / *address:* SPEC (Service de Physique de l'Etat Condensé), CEA Saclay, 91191 Gif-sur-Yvette

Lieu du stage / *internship place*: idem

Titre du stage / *internship title*:

Electron Spin Resonance of Individual Spins in Solids

The detection and characterization of paramagnetic species by electron-spin resonance (ESR) spectroscopy has numerous applications in chemistry, biology, and materials science. Most ESR spectrometers rely on the inductive detection of the small microwave signals emitted by the spins during their Larmor precession into a microwave resonator in which they are embedded. The best spectrometers so far are able to detect typically the presence of 10^7 spins in a single experimental sequence.

Since a few years, within the framework of an ERC project, we are engaged in a research program that aims at improving enormously the sensitivity of ESR spectroscopy, using superconducting micro-resonators of very high quality factors and ultra-low-noise microwave amplifiers based on Josephson junctions (called Josephson Parametric Amplifiers or JPA), cooled at 10mK in a dilution refrigerator. A patent has been deposited on this idea.

In 2014-2015, using bismuth donors in silicon coupled to an aluminum micro-resonator, with a JPA to amplify the signal, we have already demonstrated the detection of 1700 spins with unity signal-to-noise ratio, which constitutes a gain of 10^4 in sensitivity compared to the state-of-the-art [1,2].

The goal of the internship is to go further than these first experiments, and to reach the sensitivity to detect individual spins. The extra 3 orders of magnitude sensitivity gain that we need to gain will be obtained by scaling down even further the resonator transverse dimensions, by introducing a narrow short constriction of length 200 nm and width ~20nm for a 15nm height in the resonator. This will enhance the spin-resonator coupling by 2 orders of magnitude, and should enable the first detection of individual spins with microwave signals. The spins to detect are of 2 kinds: NV centers in diamond, or Bismuth donors in silicon.

This experimental internship will cover: optical detection and characterization of individual NV centers in diamond using a confocal microscope, fabrication by cleanroom techniques of the micro-resonator with nanometric constriction, and measurement at millikelvin temperatures using a dilution refrigerator fully equipped with microwave equipment. In addition of the supervisor, the student will work with a 3rd year PhD student and a postdoc.

[1] A. Bienfait et al., arxiv:1507.06831, accepted in Nature Nanotechnology (2015)

[2] A. Bienfait et al., arxiv:1508.06148, submitted to Nature (2015)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : yes**

Si oui, financement de thèse envisagé/ *financial support for the PhD***: CFR (CEA) or EDPIF**

Lumière, Matière, Interactions	**X**	Lasers, Optique, Matière	**X**