INSTITUT NEEL Grenoble

Proposition de stage Master 2 - Année universitaire 2016-2017

Graphene based superconducting quantum bits

Cadre général :
The future of nanoelectronics will be quantum. Downscaling in electronics as now reached a point where the size of the devices (less than 10 nm) means that their quantum behavior must be taken into account. While this might be seen by some industries as a major problem this also gives a real opportunity to rethink the way electronics works and make devices with new quantum functionalities.
A key building block for future quantum electronics systems is the quantum bit. Such system has two possible states (0 and 1) but they follow the law of quantum mechanics. One example is that one might build any superposition of 0 and 1. This will have implications for building future quantum computers.

Sujet exact, moyens disponibles :
In this work we want to build a new type of device to implement a quantum bit that we hope will have strong advantages over other competing systems. The idea is to use the know-how that has been developed in the superconducting quantum bit community over the past 20 years and integrate in the core of the system a semiconducting material coupled to superconducting contacts to bring novel electrical functionality to the device. We will use graphene, a two dimensional zero band gap semiconductor [Nov04]. The team has a strong expertise in graphene[Ren14,Han14] that will be at the core of this project. A sheet of graphene will have to be integrated into a superconducting quantum bit design [Koc07] using nanofabrication techniques as illustrated in Figure 1.
Such sample will then be measured at very low temperature (20mK) in a dilution refrigerator using radiofrequency (1-10 GHz) techniques. This will allow to demonstrate that the system behaves as a two-level system and to show that its energy levels can be tuned with an electric field. After this demonstration, more involved measurements will be carried out in the following PhD project (lifetime, coherence, coherent manipulation...).

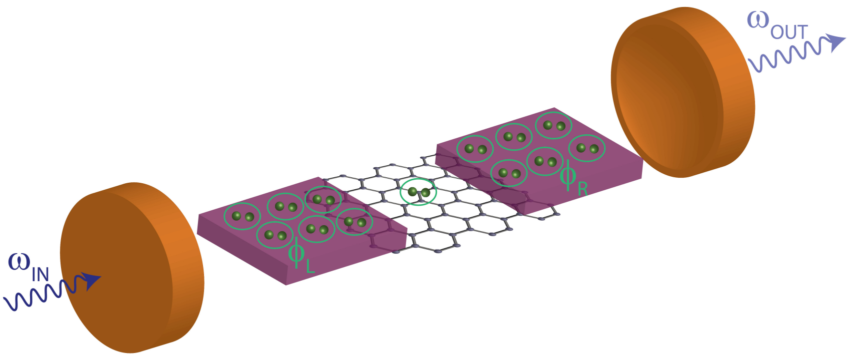

Figure 1: A Josephson Junction, i.e. a weak link between two superconducting regions, is made using graphene. Radiofrequency techniques are used to probe the system

[Han14] Z. Han et al *Nature Physics* **10**, 380 (2014)
[Koc07] J. Koch et al *Phys. Rev. A* **76**, 042319 (2007)
[Nov04] K.S. Novoselov et al *Science* **306**, 666 (2004)
[Ren14] J. Renard et al *Phys. Rev. Lett.* **112**, 116601 (2014)

Interactions et collaborations éventuelles : The work will be carried out in the Hybrid team. See our website for more details (http://neel.cnrs.fr/spip.php?rubrique621). The team has also several external collaborations worldwide (France, Germany, Canada).
Ce stage pourra se poursuivre par une thèse(ou **ce sujet est limité à un stage M2**...).Yes
Formation / Compétences : The internship (and the PhD thesis) will require a solid background in solid state/condensed matter physics. The work will be mainly experimental. The candidate is expected to be strongly motivated to learn the associated techniques (nanofabrication in clean room, radiofrequency electronics, cryogenics...) and engage in an hands-on experimental work.
Période envisagée pour le début du stage : March 2017 (flexible)

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