International Research Laboratory "Quantum Frontiers Lab"

Laboratoire de Recherche International "Laboratoire Frontières Quantiques"

entre le CNRS et l'Université de Sherbrooke

Propositions de stage des collaborateurs français

Année 2022

Proposition de stage / Internship proposal

Année 2022

Date de la proposition :

Responsable du stage / *internship supervisor*: Dorothée Colson

Nom / *name*: Colson Prénom/ *first name* : Dorothée

Tél : 33 1 69087314 Courriel / *mail*: dorothee.colson@cea.fr

Nom du Laboratoire / *laboratory name*: Service de Physique de l'Etat Condensé (SPEC) / LNO

Etablissement / *institution* : CEA Code d'identification : UMR 3680

Site Internet / *web site*: : https://www.speclno.org/

Adresse / *address:* CEA Saclay, 91191 Gif sur Yvette Cedex

Lieu du stage / *internship place*: SPEC/LNO CEA Saclay, Bât 771, Orme des Merisiers, 91191 Gif sur Yvette Cedex

Montant du financement de stage proposé / *Financial support for the internship: par mois 2000$ + 600€*

Titre du stage / *internship title*: Exploring the physics of correlated metallic Kagome networks

Résumé / *summary*

Strong electronic correlations give rise to exotic forms of electronic orderings, such as high temperature superconductivity or colossal magnetoresistance. In parallel, solid-state physics has been shaken recently by the discovery of topological materials, where exotic fermions, such as Dirac or Weyl fermions have been discovered. Both properties are actively studied, but they rarely coexist in the same materials. Most topological materials known today are weakly correlated semiconductors, which are rather well described by band theory, unlike correlated systems. Finding similar properties in correlated systems could add new dimensions to the problem. Magnetism is for example common in correlated transition metal, giving rise to new topological properties.

We propose the study of systems containing Kagome planes of transition metals (Fe, Co, Rh…), which intrinsically bring together strong correlations and topologically non-trivial band structures. One example is the magnetic Weyl semimetal $Co_3Sn_2S_2$, which display a record large anomalous Hall effect, but where the strength and the role of correlation in these systems are still largely unknown.

The student will synthesize and characterize single crystals of the pure compound and to study the modifications of its properties by chemical substitution (Fe,Ni,Rh...).
A peculiar attention will be given to the structural and physical properties of crystals by using X-rays diffraction measurements (powder and single crystal) and magnetism (Squid, VSM).
This internship will be carried out in close collaboration with the team of Véronique Brouet of the Laboratoire de Physique des Solides at Orsay. Angular resolution photoemission experiments at the SOLEIL synchrotron could be performed during the internship to study its electronic band structure and verify the presence of topological and/or correlated properties.

Techniques/methods in use: Crystal growth, EDS analysis, X-rays diffraction, magnetic measurements, Angle Resolved Photoemission.

Proposition de stage / Internship proposal

Année 2022

Date de la proposition : 10/01/2022

Responsables du stage / *internship supervisor*:

Nom / *name*:	Prénom/ *first name* :
MENDELS	Philippe
BERT	Fabrice

Tél : +33 1 69155339 / 5998 Courriel / *mail*:philippe.mendels@universite-paris-saclay.fr
fabrice.bert@universite-paris-saclay.fr

Nom du Laboratoire / *laboratory name*: Laboratoire de physique des solides

Etablissement / *institution* : CNRS-Université Paris-Saclay Code d'identification : UMR 8502

Site Internet / *web site*: www.lps.u-psud.fr ; groupe : https://www.lps.u-psud.fr/equipes-scientifiques/sqm

Adresse / *address:* Bât 510. Université Paris-Saclay, Faculté des sciences, 91405 Orsay

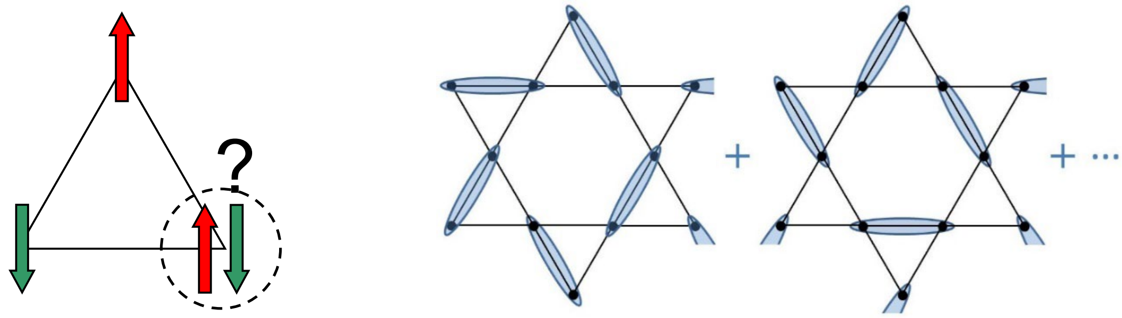
Lieu du stage / *internship place*: Groupe Spectroscopie des Matériaux Quantiques (SQM)

Montant du financement de stage proposé / *Financial support for the internship: par mois :* 2000$ + 600€

Titre du stage / *internship title*: **Experimental study of Quantum Spin Liquids**

Résumé / *summary*

Quantum spin liquids are novel fascinating states of matter. At variance with conventional ferro- or antiferro-magnetic ground states consisting of long range ordered spins, spin liquids are highly entangled disordered states, a signature of the breakdown of the Landau – Ginzburg - Wilson paradigm of phase transitions. Quantum fluctuations are so strong that the semi-classical picture of individual spins relevant for the conventional states, breaks down completely. Instead the spins pair up to form singlets. The spin liquid states result from the quantum superposition of these individual singlets to form a macroscopically entangled state. There are many ways to make this superposition and thus many different types of possible quantum spin liquids. Which ones can actually be realized in real materials and how they can be identified are central questions. One common fingerprint of these states is the emergence of unconventional excitations, fractional spinon, emergent photon modes, majorana fermions...which can be tracked in experiments.



Left: geometrical frustration of the magnetic interaction on a triangular lattice. Right: one possible spin liquid state on the kagome lattice. The ellipses represent singlet states from two paired spins.

Magnetic **frustration** has been recognized and used for long as a successful mechanism to favor these exotic states for quantum (spin-1/2) antiferromagnets: all the richness of this concept is illustrated by the ½ award of the Nobel Prize to G. Parisi this year. Several such materials like herbertsmithite or barlowite –initially natural minerals- are now synthesized and investigated worldwide and in our group for their unique magnetic properties.
We propose to investigate such novel spin liquid materials provide by our french consortium supported by the National Research Agency or well established international collaborations, using our state of the art NMR setups together with low temperature thermodynamic measurements and possibly complementary muon spin relaxation/ neutron scattering techniques available at large scale facilities.

Keywords: physics, solid state physics, quantum magnetism, frustration, correlations, spin liquids, resonance

Skills: Good fit for experiments and solid background in slid state physics at Master 2 level are required.

Proposition de stage / Internship proposal

Année 2022

Date de la proposition :

Responsable du stage / *internship supervisor*:

Nom / *name*: Aprili/Gabelli   Prénom/ *first name* : Marco/Julien

Tél : +33169155322 ++33169155365   Courriel / *mail*: marco.aprili@u-psud.fr, julien.gabelli@u-psud.fr

Nom du Laboratoire / *laboratory name*:

Etablissement / *institution* :LPS-ORSAY   Code d'identification :UMR8205

Site Internet / *web site*: https://www.lps.u-psud.fr, https://www.equipes.lps.u-psud.fr/ns2/index.shtml

Adresse / *address:* Bât. 510, Université Paris-Saclay

Lieu du stage / *internship place*: Laboratoire de Physique des Solides - Orsay

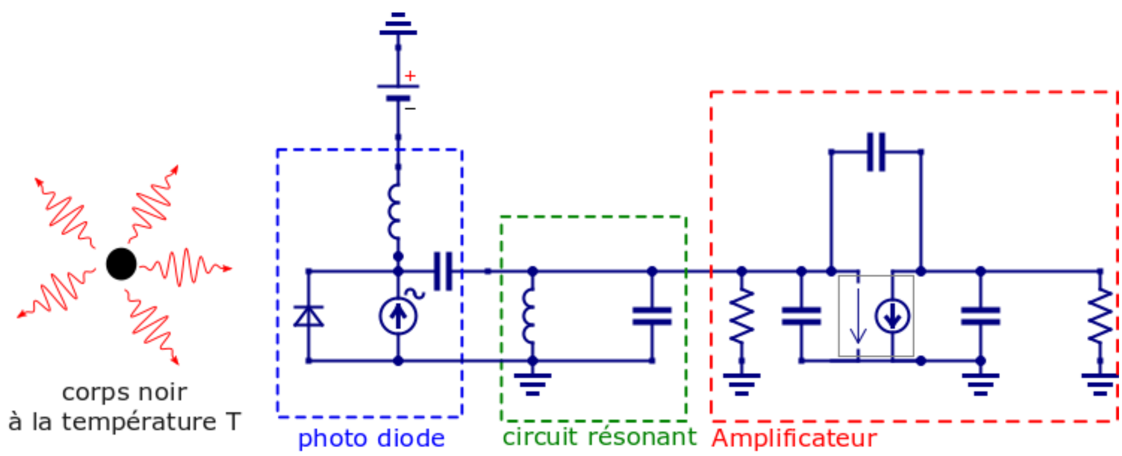
Montant du financement de stage proposé / *Financial support for the internship: par mois : 2000$ +600€*

Titre du stage / *internship title*: **Amplificateur cryogénique pour l'étude des fluctuations du nombre de photons**

Résumé / *summary*

L'étude des fluctuations d'intensité d'une source de lumière permet de mettre en évidence le caractère corpusculaire de la lumière. Nous proposons de développer et réaliser un amplificateur cryogénique qui permettra de mesurer des fluctuations d'intensité lumineuse de sources très peu brillante.

L'amplificateur sera composé d'un transistor FET bas bruit associé à une photodiode insérée dans un circuit LC supraconducteur (voir schéma ci-dessous). Le stage sera consacré dans un premier au développement de l'amplificateur et du circuit résonant à l'aide d'un simulateur de circuit électronique. Des mesures de fluctuations du nombre de photons d'un corps noir à basse température (entre 2.8 et 50 K) seront ensuite réalisées pour tester le détecteur.



Proposition de stage / Internship proposal

Année 2022

Date de la proposition : 16-12-2021

Responsable du stage / *internship supervisor*: Alain Sacuto et Maximilien Cazayous

Nom / *name*: SACUTO Prénom/ *first name* : Alain

Tél : 33157276236 Courriel / *mail*: alain.sacuto@u-paris.fr

Nom du Laboratoire / *laboratory name*: Matériaux et Phénomènes Quantiques

Etablissement / *institution* : Université de Paris Code d'identification : (SIRET :13002573700011)

Site Internet / *web site*: https://u-paris.fr/

Adresse / *address:* Bâtiment "Les Grands Moulins"**,** 5 rue Thomas Mann, 75013 Paris
Esplanade Pierre Vidal-Naquet, 75013 Paris

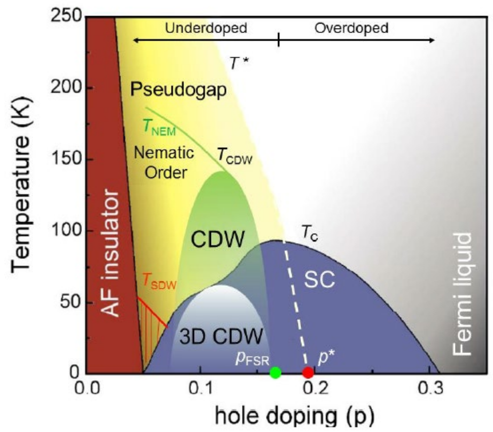
Lieu du stage / *internship place*: laboratoire Matériaux et Phénomènes Quantiques

Montant du financement de stage proposé / *Financial support for the internship: par mois 2000$ + 600€*

Titre du stage / *internship title*: **Monitoring and increasing the Superconducting Transition temperature in Cuprates by uniaxial constraint**

Résumé / *summary*

Superconductivity is a fascinating quantum state of matter. Well understood in standard metals, it remains largely misunderstood in copper oxides, called cuprates. Cuprates exhibit exceptionally high superconducting transition temperature Tc that it can be monitored by doping and pressure. Superconductivity occurs on the backdrop of an antiferromagnetic insulator at low doping and develops on a large doping range from strange metallic phase called the pseudogap phase (hosting a charge-density wave order) to a more an ordinary metal. Our work has given major contributions in this field [1-3].



In order to control the critical temperature Tc and unveil the mechanism at the origin of the pairing of electrons in the superconducting cuprates, the aim of this internship is to study one of the most known cuprate $YBa_2Cu_3O_7$ (Tc =92 K) under a new technique namely: the uni-axial strain (compression and tension).

Our favourite probe is the electronic Raman scattering which allows us to directly probe the density of states and give us access to the binding energy of the cooper pairs in the particle-particle channel, the charge density wave in the particle –hole channel and finally the pseudogap phase.

The aim of this work will be to study the evolution of the binding energy of the cooper pair under pressure by combining the two techniques: Raman spectroscopy and uniaxial strain in order to unveil the effect of the electronic and lattice anisotropy on superconductivity in cuprates. This Internship which can be continued in thesis. This Work will be carried out in collaboration with D. Colson (CEA SPEC), I. Paul (MPQ), M. Civelli (LPS, Orsay) for theoretical support.

[1] *La supraconductivité dans les oxydes de cuivre* : Où en est-on? , Les reflets de la Physique , 70, octobre 2021
[2] *Exploration of the Hg-based cuprate superconductors by Raman spectroscopy under hydrostatic pressure,* N. Auvray, et al., Phys. Rev. B 103, 195130 (2021).
[3] *Intimate link between Charge Density Wave, Pseudogap and Superconducting Energy Scales in Cuprates,* B. Loret, et al., Nat. Phys. 15, 771 (2019).