Master 2

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Solides
CNRS identification code: UMR 8502
Internship director'surname: SIMON Pascal / MESAROS Andrej
E-mail: pascal.simon@universite-paris-saclay.fr / andrej.meszaros@universite-paris-saclay.fr
Web page: https://www.equipes.lps.u-psud.fr/Simon/
Internship location: Orsay
Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Title: **Topological superconductivity with magnetic skyrmions**

Topology plays a major role in the field of magnetism and superconductivity, two historical pillars of solid state physics. Magnetic systems may give rise to curious topological spin textures in real space such as skyrmions, which have been attracting enormous attention in view of their potential applications in information storage and due to the fact that they can be controlled and manipulated. In superconducting materials, vortices are basic well-known topological objects that appear when some superconductors are subject to an external magnetic field. What happens when both these topological objects come into play in hybrid superconductor-ferromagnet (SF) structures?

We have recently shown that topological superconductivity can be induced by proximitizing skyrmions and conventional superconductors, without the need for additional ingredients [1]. Topological superconductivity is characterized by Majorana fermions, which are neutral exotic electronic excitations with potential applications in quantum computation due to their non-Abelian statistics. We found that such a heterostructure has a Majorana zero mode in the core of the skyrmion and a chiral band of Majorana modes on the edge of the skyrmion [1].

During this internship, the student will better characterize theoretically this composite skyrmion-vortex bound object by first analyzing its transport properties. This will be achieved based on the software package KWANT [2] together with a combination of analytical calculations based on low-energy effective Hamiltonians. If time allows, we will go beyond this single vortex-skyrmion object and study their fusion and braiding properties under an adiabatic time evolution.

[1] M. Garnier, A. Mesaros, P. Simon, Topological superconductivity with deformable magnetic skyrmions, Communications Physics 2, 126 (2019).
[2] C.W. Groth, M. Wimmer, A.R. Akhmerov, X. Waintal, New Journal of Physics 16, 063065 (2014).

Profile: Condensed matter theory, superconductivity, magnetism, quantum transport.

Please, indicate which specialities seem to be more adapted to the subject:

Condensed Matter Physics: YES Quantum Physics: YES
Theoretical Physics: YES