Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de Physique des Solides
CNRS identification code: UMR8502
Internship director'surname: Pascal SIMON/Andrej MESAROS
e-mail: pascal.simon@universite-paris-saclay.fr, Phone number: : +33 169156090
andrej.mesaros@universite-paris-saclay.fr
Web page: https://equipes2.lps.u-psud.fr/pascal-simon/
https://equipes2.lps.u-psud.fr/andrej-mesaros/
Internship location: University Paris Saclay, Bat. 510, 91405 Orsay Cedex
Thesis possibility after internship: YES
Funding already obtained for a PhD: YES If YES, which type of funding: ANR

Amorphous (superconducting) topological matter

Tremendous progress has been achieved in the past decade in our understanding of the electronic properties of quantum matter and topologically protected states. This has been possible by realizing that the electronic wave function, a rather abstract object, does contain important information that can be classified by topology and which is not encoded in the energy spectrum. One of the main characteristics of topological phases of matter is their robustness to local perturbations and the existence of topologically protected edge states. Most of our understanding of topological materials was developed by studying crystalline materials, therefore assuming translational invariance and the existence of a reciprocal space.

Because topological classifications do not depend on translational invariance, there is no reason why they could not extend from crystalline to amorphous materials, since the latter crucially differ from the former only by lacking long-range translational order. Motivated by this, a few recent works have found topological states in amorphous systems, both in theory and in experiment (see [1] for a recent review). Intriguingly, amorphousness may stabilize topological states with increased robustness, while the fact that some symmetries survive on average in these disordered systems in principle allows a zoo of symmetry-protected topological states which are analogous, but different, than their crystalline counterparts. A key challenge remains how to identify and distinguish various amorphous topological states, while almost nothing is known in particular about amorphous topological superconductors.

In this internship, we would like to investigate one of the oldest toy models for amorphous matter, the Weaire-Thorpe (WT) model [2] enriched by an internal flux variable to ensure non-trivial chiral topological states [3]. The first purpose of this internship is to analyze whether topological superconductivity (and associated chiral Majorana edges modes) can be induced in the WT model by the proximity of a normal superconductor (which injects Cooper pairs into the amorphous material) and analyze the associated phase diagram. Next, we shall inquire on the possibility of intrinsic superconductivity by adding attractive interactions in the WT model and treating them self-consistently at the mean field level.

[1] P. Corbae et al., arXiv:2301.04176, Euro. Phys. Lett. 142 16001 (2023).
[2] D. Weaire D. and M. F. Thorpe, Phys. Rev. B 4, 2508 (1971).
[3] Q. Marsal Q., D. Varjas and A. G. Grushin, PNAS 117, 30260 (2020).
https://www.pnas.org/content/117/48/30260

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES