Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: IJCLab
CNRS identification code: UMR 9012
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Internship location: Bat. 108, Université Paris-Saclay Campus, Orsay

Thesis possibility after internship: YES
Funding: NO (Possibility of application to EDPIF for funding)

Non-linear circuit elements with voltage-biased superconductors

One of the most important features of superconductors is the ability to conduct electricity with zero resistance. A finite electric field is incompatible with the zero-resistance state and therefore, an applied voltage causes a suppression of superconducting order. The current-voltage relation of a voltage-biased superconductor exhibits strongly non-monotonic features with negative differential conductance, which can find potential applications in switching devices and sensor technologies.

In this internship, we will investigate the transport properties of thin films of the alloy Nb_xSi_{1-x}. The experiments are motivated by problems pertinent for both fundamental and applied research. The critical temperature of Nb_xSi_{1-x} can be controlled by varying the level of disorder. Depending upon the composition and thickness, the ground state [1,2] at low temperature may be either superconducting, metallic or insulating. There are many open questions regarding the nature of electronic correlations present in the metallic and insulating states arising out of a disordered superconductor. One particular objective of these experiments is to gain insights about the phenomenon of superconductivity in these systems by studying the impact of an electric field on the onset of the phase transition.

In recent years, the fabrication of diode-like devices with superconductors has attracted a lot of attention, motivated by the prospect of designing electrical circuits for computing with low power consumption [3]. A second objective of the experiments carried out during this internship is to study the possibility of designing circuit elements having bistable current-voltage relations. These can be used to model complex non-linear networks that are pertinent for different technological applications.

[1] Sacépé et al., "Quantum breakdown of superconductivity in low-dimensional materials", Nature Physics 16, 734 (2020)
[2] Humbert et al., "Overactivated transport in the localized phase of the superconductor-insulator transition", Nature Communications 12, 6733 (2021)
[3] Ando et al., "Observation of superconducting diode effect", Nature 584, 373 (2020)

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:	NO