ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech | université PARIS-SACLAY

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Physics, Optics ***Subfield***: Superconductivity and magnetism, Josephson transport

Title: **Fast Josephson-junction control by optical manipulation of a flux quantum**

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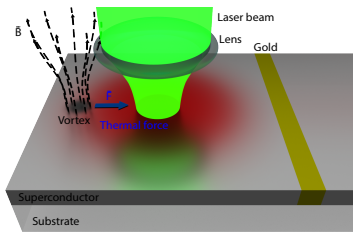
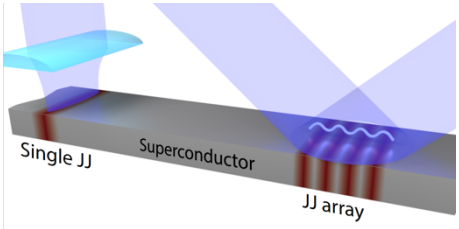
Lab location: Bordeaux
(Lab/Advisor website): https://sites.google.com/site/bordeauxnanophotonicsgroup/home

Short description of possible research topics for a PhD:

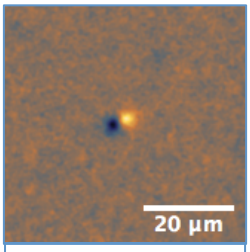
The miniaturization of semiconductor-based electronic components could reach its limits within a decade. Superconducting electronics, based on quantum flux superconducting logic circuits (Josephson junctions), is a promising alternative offering both high operating rates and low switching energies. Full optical control of Josephson junctions would enable low-power, wideband communication between logic circuits at cryogenic temperatures and room-temperature mass memories. In this context, the thesis objective is the fundamental exploration of the interplay between optics, magnetism and superconductivity, an emerging research field. Innovative optical methods of individual Abrikosov vortex manipulation recently developed in our group offer promising perspectives such as fast optical Josephson junction control by moving a quantum of flux near a junction by photo-thermal effect.



Control of a Josephson junction with a single vortex.



Sculpting a normal region in a superconductor with light.



Generation of a vortex-antivortex pair with a laser pulse.

We will also aim at creating the Josephson junction itself by photo-thermal effect, by illuminating the section of a superconducting ribbon. The Josephson electrical transport signatures will be studied according to the geometry and power of the laser beam used to locally weaken the superconductivity. Finally, in the perspective of an all-optical control of superconducting electronic devices, part of the thesis will be dedicated to the creation of flux quanta with a laser pulse, using the inverse Faraday effect.

Required background of the student: quantum physics, optics, light matter interaction, superconductivity and magnetism.

A list of representative publications of the group:

« Optical Manipulation of Single Flux Quanta», I. S. Veschunov et al. Nature Communications 7 (2016) 12801.
Patent "Control of the displacement of an individual Abrikosov vortex », A. Bouzdine, B. Lounis, P. Tamarat.
"Anomalous Josephson effect controlled by an Abrikosov vortex", S. Mironov et al., PRB 96, 214515 (2017).
"On-Demand Optical Generation of Single Flux Quanta" A. Rochet et al. Nano Letters 20 (2020) 6488.