ParisTech

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

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

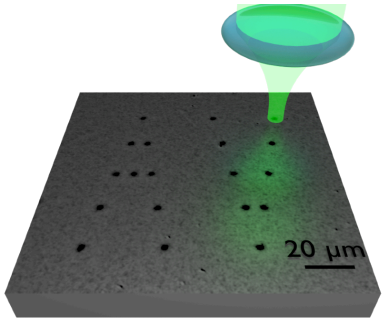
Field: Physics, Optics ***Subfield***: Quantum physics, molecular physics, condensed matter

Title: **Towards single spin control with an optically driven Abrikosov vortex**

ParisTech School: Institut d'Optique Graduate School
Advisor(s) Name: Brahim LOUNIS, Philippe Tamarat
Advisor(s) Email: brahim.lounis@u-bordeaux.fr
Research group/Lab: LP2N, UMR5298/Nanophotonics group
Lab location: Bordeaux
(Lab/Advisor website): https://sites.google.com/site/bordeauxnanophotonicsgroup/home

Short description of possible research topics for a PhD:

Abrikosov vortices are the most compact magnetic objects, with a size of a few tens to a few hundred nanometers. These flux tubes, which penetrate type II superconductors (such as Niobium), carry a quantum of flux h/2e and are surrounded by super-currents. Recently, our group demonstrated the ability to manipulate single flux quanta with a laser beam, as simply as with optical tweezers.



The main goal of the doctoral project is to explore the magnetic interaction between an optically manipulated individual Abrikosov vortex and a single spin present in a quantum nano-emitter such as the nitrogen-vacancy color center in diamond. The entanglement between the vortex mesoscopic system and the spin will be studied. The 3D optical nanoscopy methods developed in our group will be applied to precisely map the distribution of magnetic field (or electric field) around a vortex. Finally, we will investigate the ability to manipulate the spin state with the magnetic field carried by the vortex.

Required background of the student: quantum physics, optics, light matter interaction, superconductivity and magnetism. The thesis will be mainly experimental. The candidate will also develop the theoretical simulations and acquire a strong background in laser spectroscopy, single photon detection, quantum optics...

A list of representative publications of the group:

1- Ivan S. Veshchunov et al., Optical Manipulation of Single Flux Quanta, Nature communications 7 (2016) 12801.
2- Bin Yang, et al., Optical Nanoscopy with Excited State Saturation at Liquid Helium Temperatures, Nature Photonics, 9 (2015) 658-662.
3- « Anomalous Josephson effect controlled by an Abrikosov vortex », S. Mironov et al. PRB 96, 214515 (2017).
4- "Optical nanoscopy with excited state saturation at liquid helium temperatures", Yang et al. Nature Photonics 9 (2015) 658.
5- "On-Demand Optical Generation of Single Flux Quanta" A. Rochet et al. Nano Letters 20 (2020) 6488.