Graduate program Light Sciences and Technologies / université de BORDEAUX

FRANCE 2030

EUR LIGHT Sciences and Technologies

PhD positions available for application

1. SELIBS - Surface-enhanced LIBS

Thesis title	SELIBS - Surface-enhanced LIBS : theoretical and experimental study of laser and plasma interactions with 3D microstructures obtained by femtosecond laser additive manufacturing.
Doctorate specialization	Lasers, Matter and Nanosciences
Research Unit	Institut de Chimie de la Matière Condensée de Bordeaux - UMR5026
Contact	**Bruno BOUSQUET** bruno.bousquet@u-bordeaux.fr

Project Summary

The SELIBS project (*Surface-enhanced LIBS*) aims at developing a new generation of substrates offering very high analytical performance in the context of multi-elemental LIBS analysis of liquids. This involves applying the principles and know-how of 3D laser additive manufacturing and the incorporation of nanoparticles at component level. An AI-based approach will be studied to deal with the large number of underlying parameters. The aim is not only to evaluate our home-made SELIBS substrates, but more generally to understand the physical parameters and interactions responsible for the improvements. Another outcome is a methodology for evaluating and comparing the analytical performance of different types of LIBS substrates dedicated to liquids analysis. This project is located at the crossroads of materials science, laser-matter interaction, plasma physics and analytical chemistry and consists of theoretical and experimental studies aimed at describing and controlling the physical interactions responsible for enhancing plasma emission.

2. Computational design of photosensitive multistate nonlinear optical 2D materials with wavelength-selective control

Thesis title	Computational design of photosensitive multistate nonlinear optical 2D materials with wavelength-selective control
Doctorate specialization	Physical chemistry
Research Unit	Institut des Sciences Moléculaires - UMR 5255
Contact	**Frédéric CASTET** frederic.castet@u-bordeaux.fr

Project Summary

The design of responsive materials allowing remote and reversible commutation of their optical properties is one of the greatest challenges for the development of photonic devices. In this context, organic photochromic compounds have been extensively studied and integrated into a variety of applications such as logic gates or optical memories. However, most of optical devices rely on linear absorption spectroscopy both for writing/erasing and reading information onto the material, which often results in destructive readout processes, since the state of the photochromic molecules is easily altered upon irradiation. Exploiting the nonlinear optical (NLO) response of the molecules for the reading step, in particular the second harmonic generation (SHG), instead confers non-destructive readout ability to the devices. In addition, the development of memory devices with high storage capacity requires introducing more than one photo-switchable component per molecular unit, which enables to create n-bit molecular spots. For practical applications, such multistate systems must however display reversible and orthogonal wavelength control, allowing each component to be controlled independently and irrespective of the order of addressing, together with significant SHG variation upon photoswitching, allowing the selective detection of each state. The first step of this research work will consist in applying computational chemistry techniques to gain an in-depth understanding of the various factors driving the efficiency of multistate NLO switches, and provide strategies towards the systematic design of optimal systems. The second step of the thesis will tackle the simulation photo-responsive functionalized surfaces, with an explicit account of dynamic and environment effects. This will constitute a major breakthrough in the rationalization of the interplay between NLO response and supramolecular arrangement, allowing for the establishment of predictive design principles for multistate NLO materials with wavelength-selective control.

3. Single Molecule Tracking through Adaptive Optics-Integrated Lattice Light Sheet Microscopy for Slice Imaging Applications

Thesis title	Single Molecule Tracking through Adaptive Optics-Integrated Lattice Light Sheet Microscopy for Slice Imaging Applications
Doctorate specialization	Neuroscience
Research Unit	Institut interdisciplinaire de neurosciences UMR 5297 - Bordeaux Imaging Center
Contact	**Daniel CHOQUET** daniel.choquet@u-bordeaux.fr

Project summary

Light Sheet Fluorescence Microscopy (LSFM), also known as selective plane illuminat microscopy (SPIM), is acclaimed in biological imaging for its rapid imaging, optical section and low phototoxicity. LSFM illuminates samples with a thin light sheet, optimizing contras thick samples. Lattice light sheet microscopy (LLSM) improves upon LSFM by reducing l sheet thickness over and extended field of view using non-diffractive beam shaping. Howe optical aberrations hinder deep imaging in thick samples. We corrected abberation integrating adaptive optics (AO) into LLSM corrects but did not consider optical aberrati upon excitation, highlighting the need for further refinement of correction methods. research aims to enhance AO-integrated LLSM by correcting aberrations in the illuminat path, implementing adaptive correction in 3D, ensuring that overall correction is faster than variations in aberrations, and automating many processes involved. Importantly, we ain integrate the super-resolution technique Single Molecule Localization Microscopy (SMLM) PAINT (Point Accumulation for Imaging in Nanoscale Topography) and DNA-PAINT of Glu subunits of α-Amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor (AMP with LLSM for nanometer-scale resolution imaging, particularly in brain slices, to adva understanding of receptor dynamics in synapses and physiological circuits.

4. Artificial intelligence and quantum simulations of frustrated many-body physics

Thesis title	Artificial intelligence and quantum simulations of frustrated many-body physics
Doctorate specialization	Physics
Research unit	Laboratoire Ondes et Matière d'Aquitaine - UMR 5798
Contact	**Ludovic JAUBERT** ludovic.jaubert@u-bordeaux.fr

Project Summary

Imagine for a moment a world where water would never freeze, even in the middle of Antarctica. What would be the physics of this world ? While this question might be moot for water, it is at the heart of frustrated systems, where order is prevented by competing interactions. This field of research is one of the most active in quantum many-body physics and has opened a window for unconventional properties of matter; spin liquids, topological phases, skyrmions … However, frustration is a double-edge sword. The ingredients responsible for its exotic properties also make it particularly difficult to study. In this PhD project, our goal is to understand the fundamental properties of frustrated systems, based on a double-front approach away from traditional methods: by developing artificial-intelligence driven methodologies, and by directly simulating these problems on quantum computers.

5. Coherent control of individual spins with Abrikosov vortices

Thesis title	Coherent control of individual spins with Abrikosov vortices
Doctorate specialization	Lasers, Matter, Nanosciences
Research unit	LP2N – UMR5298
Contact	**Philippe TAMARAT** philippe.tamarat@u-bordeaux.fr

Project Summary

The goal of this doctoral project is to explore fast, coherent and local manipulation of individual spins using optically driven Abrikosov vortices. The addressed spins will be carried by Nitrogen- Vacancy centers in diamond in their ground electronic state. The transition between spin levels will be performed by application of a microwave and red out optically via variations of the fluorescence intensity. The PhD candidate will study the influence of a local magnetic field stemming from an Abrikosov vortex (carrying a flux quantum) on the spin levels. Using an attractive photothermal force on the vortex, as with optical tweezers, fast optical drive of a vortex will be performed in the near vicinity of the color center to control its spin sublevels and operate rapid transitions between the spin states. This approach based on optically driven vortices will also be explored in the view of mediating quantum entanglement between multiple spins.