SCIENCES SORBONNE UNIVERSITÉ

cnrs

2023-2024

Master and PhD Proposal

erc insp INSTITUT DES NANOSCIENCES DE PARIS

Campus Pierre et Marie Curie
Tower 23 – 3rd floor – 23-22
Director: Massimiliano Marangolo

Title: Optically generated nanoscale magnetic field for ultrafast manipulation of magnetic domains

Keywords: Ultra-short pulses of magnetic field, plasmonic antennas, genetic optimization, light-matter interactions, inverse Faraday effect, magnetism

Scientific description:

The inverse Faraday effect allows the generation of stationary magnetic fields through optical excitation only. This light-matter interaction in metals results from creating drift currents via non-linear forces that light applies to the conduction electrons. In our group, we recently described the theory underlying the generation of drift currents in metals, particularly its application to photonic nanostructures using numerical simulations. We demonstrated that a gold photonic nano-antenna, optimized by an inverse design algorithm, allows, under high excitation power, to maximize the drift currents and generate a pulse of stationary magnetic fields in the tesla range and at the nanoscale (X. Yang *et al*, ASC nano 2022). Something that no other technique allows nowadays.

The manipulation of drift currents by a plasmonic nanostructure for the generation of stationary magnetic field pulses opens up, therefore, new and very interesting possibilities in the ultra-fast control of magnetic domains with applications in data storage technologies, but also in research fields such as magnetic trapping, magnetic skyrmion, magnetic circular dichroism, spin control, spin precession, spin currents, and spin-waves, among others.

At the interface between nanophotonics (optics at nanometer scales) and magnetism, this master and PhD project consists in using metallic nanostructures, known as optical nanoantennas, to generate strong and confined stationary magnetic fields (figure 1). At first, the successful candidate will characterise the created magnetic field using a magnetic force microscope (MFM) present in our lab. From there, more in-depth studies will follow during the course of a PhD project, involving ultra-fast optics, magnetic trapping and magneto-luminescence sensing. Collaborations with external groups are expected; students with appetence in traveling are encouraged.

This experimental master and PhD project is part of a completely new field of research with high potential both in terms of scientific publications and possible technical applications.

The student will work in close collaboration with Mathieu Mivelle, CNRS Researcher, Wajdi Chabaani, Postdoc researcher, Romeo Zapata and Ye Mou, PhD students, Eric Charron, research engineer. **For more information, visit our Webpage**.

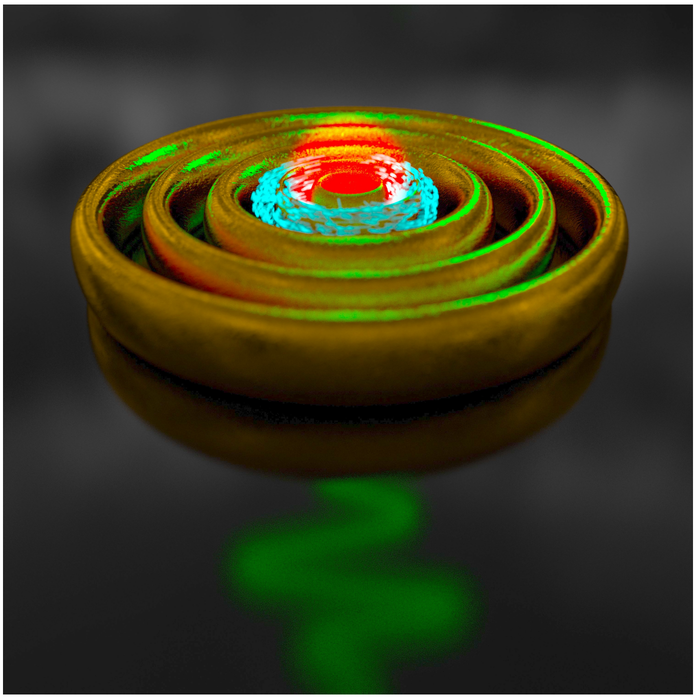

Figure 1. *Illustration of a photonic nanostructure illuminated by a short pulse of light (green oscillation), creating drift currents (blue sparks) and generating a strong stationary magnetic field (red halo).*

Techniques/methods in use: Magnetic Force Microscope, Atomic Force Microscope diamond NV-center
Applicant skills: Curiosity, Motivation and Experimental liking & skills
Industrial partnership: No
Internship supervisor: Mivelle Mathieu, mathieu.mivelle@sorbonne-universite.fr, 0144274442, Webpage.
Internship location: Sorbonne Université, INSP, 22-32, fifth floor.
Possibility for a Doctoral thesis: Yes, ERC fellowship.