PhD project

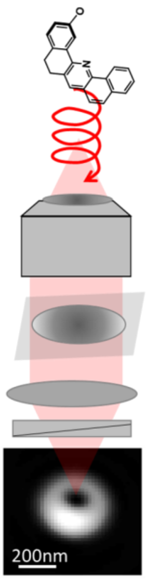
Laboratory : Institut Fresnel

phD co-Directors : Sophie Brasselet, Miguel Alonso
contacts : sophie.brasselet@fresnel.fr, miguel.alonso@fresnel.fr
Institut Fresnel, Domaine Universitaire de Saint Jérôme, 13397 Marseille
https://www.fresnel.fr/wp/en/mosaic/team/

Nanoscale imaging of chirality

The MOSAIC team at Institut Fresnel has pioneered methods in nanoscale polarimetry in 3D, in particular for monitoring the orientation of single fluorescent molecules in 3D, or to determine local complex polarization states by scattering nanoparticles, at scales below the diffraction limit. These approaches are of great interest in optical imaging of biomolecular assemblies and in nanophotonics. The principle is based on the manipulation of phase and light polarization in the pupil detection plane of a microscope, followed by the analysis of the shape of the image of the emitter (molecule, nanoparticle). This is applicable in both fluorescence and scattering (e.g. dark field) microscopy, which allows to expand the range of possible applications from super resolution structural biological imaging to nanoplasmonics.

A still missing element of these methods is the possible presence of circular or elliptic polarizations in the radiation explored. Emitters considered so far are indeed radiating light in the form of linear radiating dipoles, oriented in 3D. It is known however that nanostructures assembled/illuminated in a chiral geometry (i.e. not superimposable to their mirror symmetry) produce intense local circularly polarized fields, while chiral molecules can produce circularly polarized fluorescence. Both situations are of high interest: chiral nanostructures are capable of enhancing the efficiency of nanophotonics devices or biosensing, while chiral molecular labels are capable of reporting the chirality of their local environment, signature of protein's denaturation for instance. The goal of this PhD project is to expand super-resolution 3D polarimetry to the imaging of single chiral emitters.



The project will cover (1) the development of appropriate formalisms for the imaging of chiral emitters, (2) the implementation of dedicated microscopy instrumentation to probe chirality from fluorescence or scattering sources, and (3) the application of this scheme to nanoscale 3D chiral imaging and probing, in chiral nanostructures produced by dielectrics or metallic nanostructures, and in single molecules in vitro and in cells. The samples will be developed together with collaborators from biology and nanoscience laboratories.

Reference: *S. Brasselet, M.A. Alonso, Polarization microscopy: from ensemble structural imaging to single molecule 3D orientation and localization microscopy. Minireview. Optica 10 (11), 1486-1510 (2023) doi.org/10.1364/OPTICA.502119*