INTERNSHIP PROPOSAL

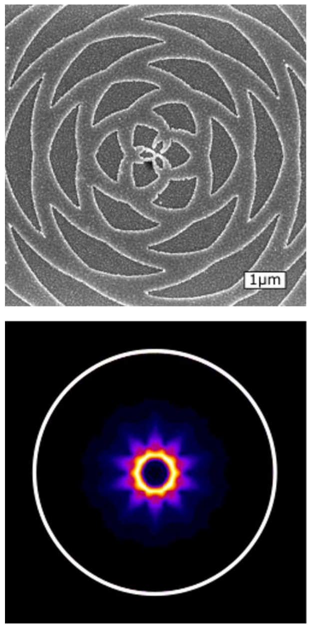
Laboratory name: Laboratoire Matériaux et Phénomènes Quantiques
CNRS identification code: UMR 7162
Name of Internship director: Aloyse DEGIRON
e-mail: aloyse.degiron@u-paris.fr Phone number: +33157276226
Web page: https://mpq.u-paris.fr/don/
Internship location: 10 rue Alice Domon et Léonie Duquet 75013 PARIS.

Thesis possibility after internship: YES
Funding: YES: EU funding, ANR grant projects currently under examination, and the Ecole Doctorale Competition.

Tying knots of darkness with incoherent light

Scientific project: the past few years have witnessed impressive developments in optical sources capable of emitting light with non-trivial phase and/or polarization patterns, such as optical vortices, vector beams or Airy beams. These structured beams are of interest in many scientific fields ranging from sub-diffraction imaging techniques (Nobel Prize 2014) to optical tweezers (Nobel Prize in 2018). Because structured beams are carved by carefully tailored interferences, their construction requires light possessing a high degree of coherence—typically light produced by a laser.

One research direction pursued by our team is to achieve the same feat with sources of non-lasing light. Non-lasing light (e.g. light from the sun, from LEDs, from burning candles…) lacks of the coherence properties of lasers, meaning that it is not in principle possible to shape all the emitted photons into a single beam—let alone a complex beam such as an optical vortex in which light spirals around a central phase singularity. Our strategy to overcome this fundamental limit is to hybridize a luminescent medium (made of colloidal nanocrystals) with a structured pattern (i.e. a “metasurface”). Rather than emitting random photons in free space, the luminescent medium will emit light with properties dictated by the metasurface. We have already validated these ideas for optical vortices and beams with azimutal polarization [1,2].



An experimental meta-surface to generate intefering vortices (top) and the resulting light beam when hybridized with luminescent nano-crystals (bottom) [1].

The goal of this internship is to generalize these results to vortex knots and vortex links, which are beams with dark phase singularities that form non-trivial topologies such as interlaced or knotted loops [3,4]. The work will include calculations, cleanroom fabrication and optical characterization, with the help of a PhD student of the team.

References

[1] D. Schanne, S. Suffit, P. Filloux, E. Lhuillier, and A. Degiron, Phys. Rev. Appl. 14, 064077 (2020).
[2] A. Caillas, S. Suffit, P. Filloux, E. Lhuillier, and A. Degiron, Nano Lett. 22, 2155 (2022).
[3] J. Leach, M.R. Dennis, J. Courtial, M.J. Padgett, Nature 432, 165 (2004).
[4] M.R. Dennis, R.P. King, B. Jack, K. O’Holleran, M.J. Padgett, Nature Phys. 6 (2010).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES