

**RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM**

**Field: Physics, Optics Subfield:** Quantum Optics

**Title:** Coherent dipole-dipole coupling of organic molecules at cryogenic temperatures

**ParisTech School:** Institut d'Optique Graduate School

**Advisor(s) Name:** Brahim LOUNIS, Jean-Baptiste Trebbia

**Advisor(s) Email:** [brahim.lounis@u-bordeaux.fr](mailto:brahim.lounis@u-bordeaux.fr)

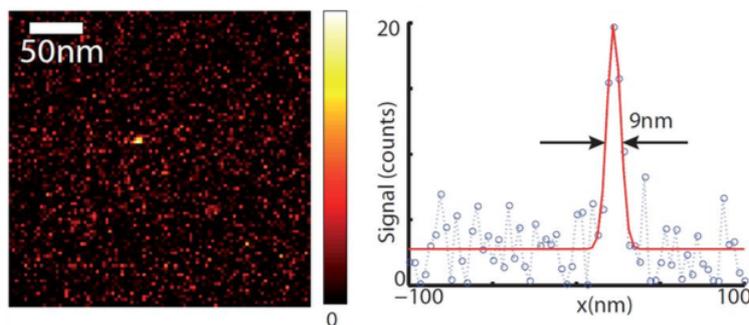
**Research group/Lab:** LP2N, UMR5298/Nanophotonics group

**Lab location:** Bordeaux

**(Lab/Advisor website):** <https://sites.google.com/site/bordeauxnanophotonicsgroup/home>

**Short description of possible research topics for a PhD:**

The controlled, coherent manipulation of quantum systems is an important challenge in modern science, with significant applications in quantum technologies. Solid-state quantum emitters such as single molecules, quantum dots and defect centers in diamond are promising candidates for the realization of quantum bits and quantum networks. Collective quantum dynamics resulting from coherent dipole–dipole coupling is challenging, since they require



nanometric distances between emitters, the degeneracy of their optical resonances and low temperatures. We will aim at developing experimental schemes to find coupled quantum emitters and manipulate their degree of entanglement with external fields. The optical super-resolution nanoscopy technique built in the

group (with sub 10-nm far-field optical resolution at cryogenic temperatures) will be used to reveal the rich space-frequency signatures of coherent coupled quantum emitters. The formation of collective quantum states from coupled optical emitters being a general phenomenon, these experimental schemes can also be useful for the study of many other systems including light harvesting complexes polymer conjugates, quantum dots molecules and hybrid systems.

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

**A list of representative publications of the group:**

- 1- A solid state source of photon triplets based on quantum dot molecules, M. Khoshnegar *et al.*, Nature Communications 8 (2017) 15716.
- 2- Optical Manipulation of Single Flux Quanta, I. S. Veshchunov *et al.*, Nature Communications 7 (2016) 12801.
- 3- Optical Nanoscopy with Excited State Saturation at Liquid Helium Temperatures B. Yang, *et al.*, Nature Photonics, 9 (2015) 658-662.
- 4- Indistinguishable near-infrared single photons from an individual organic molecule J.-B. Trebbia *et al.*, Phys. Rev. A. 82 (2010) 063803.
- 5- 3D optical nanoscopy with excited state saturation at liquid helium temperatures, J.-B. Trebbia, R. Baby, P. Tamarat, and B. Lounis, Optics Express, 27 (2019) 23486