

Research Topic for the ParisTech/CSC PhD Program

**Field (cf. List of fields below): Physics, Optics*

Subfield: Quantum optics

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

ParisTech School: Institut d'Optique Graduate School (LP2N, UMR 5298)

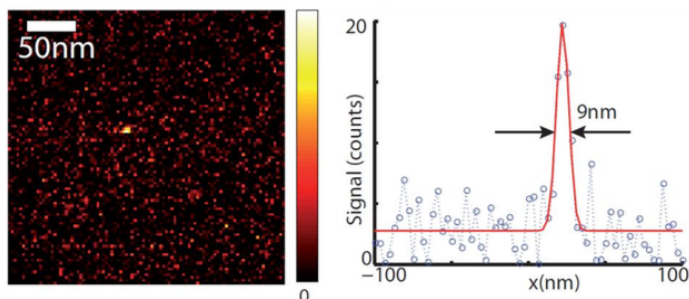
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(Lab, website) : <https://sites.google.com/site/bordeauxnanophotonicsgroup/home>

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. Because coupling mechanisms such as dipole-dipole or tunneling occur on a nanometer scale, it is crucial to develop experimental schemes that optically resolve quantum emitters at this scale and allow the manipulation of their degree of entanglement. Recently, we introduced a simple super-



resolution optical nanoscopy method operating at cryogenic temperatures and achieved a sub 10-nm far-field optical resolution. We propose to use this technique to reveal the rich space-frequency signatures of coherent coupled quantum emitters and manipulate on demand their degree of entanglement.

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 mechanics, optics, light matter interaction.

The candidate's thesis will be mainly experimental. He/she will also develop the theoretical simulations necessary for the results interpretation. He/she will acquire a strong background in laser spectroscopy, single photon detection, quantum physics...

A list of 5(max.) representative publications of the group:

- [1]-M. Khoshnegar, *et al.*, **A solid state source of photon triplets based on quantum dot molecules**, Nature communications 8 (2017) 15716.
- [2]-Ivan S. Veshchunov *et al.*, **Optical Manipulation of Single Flux Quanta**, Nature communications 7 (2016) 12801.
- [3]-Bin Yang, *et al.*, **Optical Nanoscopy with Excited State Saturation at Liquid Helium Temperatures**, Nature Photonics, 9 (2015) 658-662.
- [4]-J.-B. Trebbia *et al.*, **Indistinguishable near-infrared single photons from an individual organic molecule**, Phys. Rev. A., 82 (2010) 063803.