Centre DE Nanosciences & DE Nanotechnologies

PhD proposal
Photonic crystal waveguides for strong atom-photon interaction

Light-matter interaction at the single-quanta level is the keystone of quantum information science. However, single quanta are generally weakly interacting and enhancing this coupling has been the driving force for a large community and the development of the cavity quantum electrodynamics[1] (CQED), where single atoms and single photons can be strongly coupled via a high-finesse cavity. The resulting controllable coupling led to a better understanding of fundamental aspects of light-matter interaction and to various seminal demonstrations.

Very recently, integrated photonic nanostructures appeared as a promising avenue of tailoring light-matter interaction by engineering the emitter environment. Modern nanofabrication techniques have indeed enabled to design solid-state systems with embedded emitters, such as quantum dots in photonic crystal waveguides or in nanocavities with high-quality factors, leading to Quantum Nanophotonics. In this context, we explore the waveguide QED approach by trapping atoms close to photonic crystal waveguides exhibiting slowly propagating modes, reaching strong interaction without a cavity.

A PhD position is open in the TONIQ group[2] at C2N for a young scientist. C2N is a research unit of CNRS and University Paris-Sud. Its objectives are to establish a flagship laboratory for research in nanoscience and nanotechnology and to provide a large technology facility in Paris region, open to academic and industrial players in the field.

The main aim of the project is the optimization of the slow mode propagating in nanowaveguides for both achieving strong coupling with single atoms and engineering of the collective response in mesoscopic populations, making strong atom-atom interaction mediated by the slow mode possible. The PhD student will have to design and simulate photonic crystal waveguides in order to exhibit slow modes at 780 nm, the resonance wavelength of rubidium atoms. She or He will contribute to the different steps of the fabrication process in the 2800 m^2 cleanroom facility of C2N, which is one of largest in France. She or He will participate to the optical experiments to characterize the performance of the fabricated slow mode waveguides and will collaborate with Julien Laurat's team[3] at LKB (Jussieu) in the atomic experiment.

Candidate profile: The PhD should have studied quantum optics, nonlinear optics and atomic physics. She/He should be motivated to perform photonic crystal numerical simulation designs and to participate in the fabrication process. Good team work skills will be essential to optimally link the two research teams and for productive interaction with the cleanroom facility engineers.

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[1] S. Haroche and J.M. Raimond, *Exploring the quantum: atoms, cavities and photons* (Oxford Univ. Press, 2006).
[2] V. Huet et. al., *Millisecond photon lifetime in a slow-light microcavity*, Phys. Rev. Lett. **116**, 133902 (2016); Ph. Hamel, et.al., *Coupling light into slow-light photonic-crystal waveguide …*, Opt. Express **21**, 15144 (2013).
[3] N.V. Corzo, J. Raskop, A. Chandra, A.S. Sheremet, B. Gouraud, J. Laurat, *Waveguide-coupled single collective excitation of atomic arrays*, Nature **566**, 359 (2019).

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