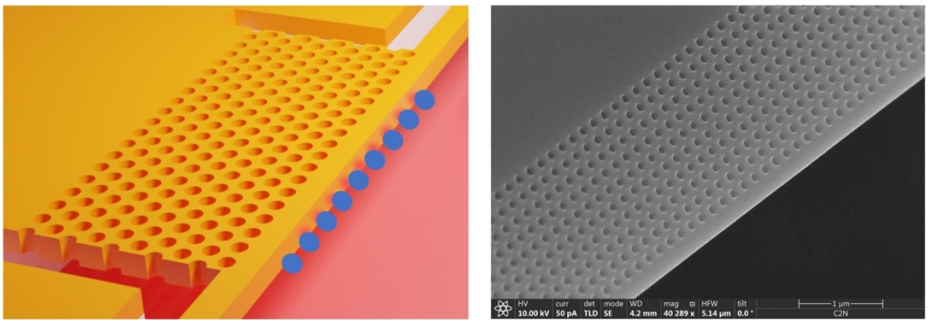
Funded PhD proposal
Photonic crystal nanostructures for strong atom-photon interaction in a quantum network

Light-matter interaction at the single-quanta level is the keystone of quantum information science and technology. However, single quanta are generally weakly interacting and enhancing this coupling has been the driving force for a large community. Integrated photonic nanostructures appear as a promising avenue for tailoring light-matter interaction by engineering the emitter environment. Modern nanofabrication techniques have indeed enabled the design of 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 paradigm by trapping atoms close to photonic crystal waveguides exhibiting slowly propagating modes. This allows for strong atom-photon coupling without a cavity, engineered collective response in a mesoscopic ensemble of atoms, and for strong atom-atom interaction mediated by the slow mode. This approach will enable new capabilities for quantum information networks, ranging from a single photon transistor to photonic quantum gates as well as quantum simulation protocols.

A funded PhD position is open in Nonlinear nanophotonic and quantum information (TONIQ) group at C2N for a young scientist. The main objective of the position is to pursue the work on this topic started few years ago in developing a novel nanophotonic platform compatible with Rb atoms and make it available to investigate waveguide QED activities in collaboration with Julien Laurat's team at LKB where an ERC project is starting on this topic.



Left: Representation of photonic crystal slow mode waveguide and the Rb atoms. Right: Scanning Electron Microscope image of a fabricated structure.

Over the past years, we have developed a nanofabrication process dedicated to nanostructures compatible with Rb atoms having an optical transition at 780 nm. During his/her PhD, the candidate will have to work on the optimization of photonic-crystal-based nanostructures seeking for the best design to reach the strong interaction regime and to propagate with minimum losses the different lasers for trapping the atoms in the vicinity of the nanostructures. The candidate will be involved in the nanofabrication process in the clean-room facility of C2N, taking benefit of the

know-how acquired over the last years. The candidate will then participate to the optical experiments to characterize the performance of the fabricated nanophotonic structures and will collaborate with Julien Laurat's team at LKB (at Sorbonne Université) bringing first the nanostructures in the cold atoms environment and working then on the atomic experiment dedicated to the strong interaction of the cold Rb atoms with the optical modes propagating in the nanostructures. The successful candidate will play a key role in this collaborative work in Paris region.

Candidate profile: The PhD candidate should have studied optics, nonlinear optics and atomic physics. She/He should be motivated to perform numerical simulations for the design, to participate in the fabrication process and to work on optical/atomic experiments. Good teamwork skills will be essential to optimally link the two research teams and for productive interaction with the cleanroom facility engineers.

Starting Date: September/October 2023
Funding: The position is funded.

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