Centre de Nanosciences & de Nanotechnologies

Seminar

Friday April 15th - 14h00

Amphithéâtre du C2N

"Intracavity Rydberg superatom for optical quantum engineering"

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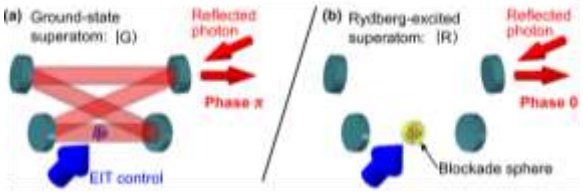
One major road towards the development of efficient photonic quantum technologies would be to rely on unitary deterministic photon-photon interactions. However, optical photons do not interact naturally. One thus has to use light-matter interactions to find ways towards effective photon-photon interactions. In the last decade, two approaches have been developed to achieve strong photon-photon interactions with cold atoms. On one side, experiments featuring a single atom strongly coupled to a cavity have a strong nonlinearity enabling the realization of quantum logic gates between two photons. On another side, experiments mapping photons onto Rydberg excitations in a cold atomic gas can also achieve strong photon-photon interactions. Nevertheless, both approaches are bounded by either technical or physical limits, keeping them far from ideal unitary deterministic photonic interactions.



In a novel apparatus, we combine these two approaches to overcome their limitations. I will present the first building blocks for quantum engineering of light with an intracavity single Rydberg superatom. We implement a coherent control of this superatom via a two-photon Rabi driving. The state of the superatom can be optically detected via the cavity transmission with a 95% efficiency. Finally, we demonstrate that our coupled system induces a 180° phase shift on the light reflected off of the cavity dependent on the superatom's state. This 180° phase rotation, together with the coherent control and the single-shot state detection, is a key ingredient for the implementation of unitary deterministic photon-photon interactions, paving the way towards quantum optics applications.

Sébastien Garcia worked on the development of fiber interfaces between single atoms and single optical photons during his PhD under the direction of Prof. Reichel at Laboratoire Kastler Brossel, Ecole Normale Supérieure (2011-2015). He did his first postdoc at Quantum Device Lab of Prof. Wallraff at ETH Zurich, mostly focusing on the detection of Rydberg atoms with superconducting microwave cavities (2016-2018). He is now a postdoc at College de France in the group of A. Ourjoumtsev. Here, his researches are dedicated on one side to, and on the other side to the realization of photon-photon interactions via Rydberg atoms in an optical cavity.