Master 2 Internship Proposal

Detection of non-local quantum properties of light in two cavities

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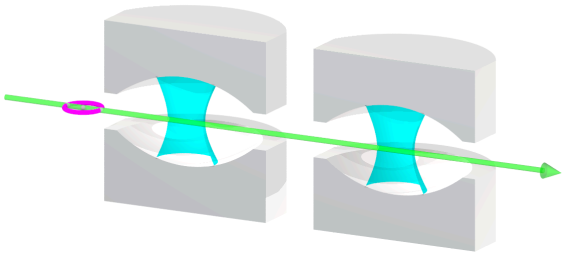
Thesis possibility after internship: **YES**
Funding: **NO**

Scientific context:

For the long time the experimental work of our team has been devoted to better understand limits of quantum properties of light and matter in the context of cavity quantum electrodynamics (cavity QED). We study fundamental quantum effects of light trapped in a high-quality superconducting microwave cavity and then probed by individual, highly excited Rydberg atoms interacting with the light and then detected one by one.



Two high-quality superconducting cavities store microwave field for several tens of microseconds. Circular Rydberg atoms cross the cavities one-by-one. Precise control of their interaction with the cavity fields allows us to prepare and then detect various non-local states of light.

Recently, the experimental setup has been upgraded with a second cavity allowing for studying non-local physics involving entanglement of different objects (cavities), which cannot be anymore described classically and separately. The simplest non-local photonic state (one photon equally shared by two cavities: the photon is only here and only there at the same time) has been generated and detected. But its full quantum characterisation is still to be performed. In the perspective, more complex light states and their quantitative analysis will be analysed.

In parallel, we plan, by using two cavities as "quantum reservoirs", to enter a new field of research – quantum thermodynamics which deals with quantum work and quantum heat transfer obeying rules of quantum micro-world.

Internship:

The goal of the internship will be to adapt and realize an experimental protocol detecting and quantifying the degree of non-locality of entangled quantum states of the two cavities. The ultimate goal is to monitor the evolution of their non-local properties towards classical (phenomenon known as quantum decoherence). During his internship in the group, the intern student will participate to the preparation and conducting of the experiment and will learn different experimental technics, like cryogenics and ultra-high vacuum, laser excitation and microwave spectroscopy of Rydberg atoms, real-time data acquisition and control of the experiment, etc. Besides, he/she will be introduced into the fundamentals of quantum optics necessary to understand the underlying physics and, in particular, several possible experimental protocols allowing for the detection and characterisation of such non-local properties of quantum states.