INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: INPHYNI
CNRS identification code: UMR 7010
Internship director'surname: Hugbart
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Web page: https://inphyni.univ-cotedazur.eu/sites/cold-atoms
Internship location:Nice

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Antibunching effect and squeezed light in a cold atom ensemble

Cold atoms coupled to photons are a promising platform for **quantum information, computation and communication**: atoms are adequate systems to store and/or correlate photons, while the photons themselves can be efficient carriers of information over great distances. The light radiated by a quantum emitter, such as an atom, generally features **quantum correlations** and **squeezing**, which are at the heart of many applications in quantum technologies. While antibunching is the key ingredient for single-photon sources, squeezed light is an important tool for sub-shot- noise quantum sensing.

Antibunching naturally occurs in the light emitted by a single quantum emitter and vanishes for many emitters. Still, antibunched and squeezed light can be obtained using many atoms: instead of collecting the atoms fluorescence, one uses the light transmitted through the atomic cloud. This has been demonstrated recently by the group of Arno Rauschenbeutel in Germany in a 1D system with cold atoms trapped and optically interfaced with an optical nanofiber [1]. This new scheme, which is based on the atoms' collectively enhanced non-linear response, is both of fundamental interest and favourable for applications. However, the nanofiber experiment requires a complex setup and is difficult to implement in practical applications.

The goal on our experiment is now to try to detect **antibunching and squeezed light with many quantum emitters in a 3D system**. This will be implemented and studied on our cold-atom experiment, taking advantage of our experience with generating clouds of cold atoms with large optical thickness, a prerequisite for this project. The experimental technique is based on intensity correlation measurement, an experimental tool largely used on our experiment to study the light scattered by a cold atomic cloud, from single to multiple scattering regime, and from classical to quantum regime [2]. The current collaboration with the group of Arno Rauschenbeutel will finally help to determine the experimental parameters needed to observe this antibunching effect.

This internship is experimental but can also include numerical studies in collaboration with Romain Bachelard (UFSCar, Brazil).

<u>References:</u>

[1] A. S. Prasad et al., Nat. Phot. 14, 719 (2020). J. Hinney et al., Phys. Rev. Lett. 127, 123602 (2021).
[2] A. Eloy et al., Phys. Rev. A 97, 013810 (2017). L. Ortiz-Gutiérrez et al., New J. Phys. 21, 093019 (2019). D. Ferreira et al., Am. J. Phys. 88, 831 (2020). P. Lassègues et al, EPJD 76, 246 (2022). P. Lassègues, et al., to appear in Phys. Rev. A (2023)

Techniques/methods in use: Laserscold atoms, intensity correlationss
Applicant skills: Experiments in optics and laser physics, basic knowledge of atomic physics

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO