UNIVERSITÉ CÔTE D'AZUR

Master thesis proposal

INPHYNI
INSTITUT DE PHYSIQUE DE NICE

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Title: **Photon condensation in hot atomic vapors**

Keywords: **Quantum fluids of light, hot atomic vapors**

Scientific description: (a figure may be included)

The goal of this project is to implement experimental tools to understand the transition from classical Rayleigh-Jeans condensation of light waves to the quantum Bose-Einstein condensation of photons. The Bose-Einstein distribution has two classical limits. In the limit where the modes are weakly occupied, it recovers the Boltzmann distribution for a classical dilute gas, whereas in the opposite limit, it recovers the Rayleigh-Jeans distribution. Rayleigh-Jeans thermalization of classical light is characterized by a wave condensation process, i.e., a phase transition toward a macroscopic population of the fundamental mode of the system. Although classical condensation differs from the quantum Bose-Einstein condensation, the underlying mathematical origin is analogous because of the common singular behaviour of the equilibrium Bose distribution for quantum particles and the equilibrium Rayleigh-Jeans distribution for classical waves.

An interesting feature of atomic vapor experiments is the possibility to control the properties of an external potential owing to an engineered modification of the local index of refraction with an auxiliary laser beam. In the experiment in our group, we will implement a smooth trapping potential using a laser tuned to the D1 line of Rubidium. We will then study the non-linear propagation, evaporation and condensation of photons close to the D2 line in this external potential. As the shape of the trapping potential can be modified in a flexible way, we can significantly increase the number of modes of the trapping, in such a way that the deviation from the classical to the quantum equilibrium should become observable even for low order modes that are weakly occupied. Preliminary theoretical studies conducted, by the group of A. Picozzi in Dijon, of the near-field and far-field averaged intensity distributions in the semi-classical approach reveals distinguished features for the Rayleigh-Jeans and the Bose-Einstein statistics. The analysis of the particle and momentum distributions may then provide a direct experimental signature of the quantum nature of photon thermalization. A collaboration with this theory group is funded by an ANR project.

Techniques/methods in use: Lasers, atomic vapor cells, spatial light modulators
Applicant skills: Experiments in optics and laser physics, basic knowledge of atomic physics
Industrial partnership: N
Internship supervisor(s) : Guillaume Labeyrie, guillaume.labeyrie@univ-cotedazur.fr
Internship location: Institut de Physique de Nice, Nice
Possibility for a Doctoral thesis: Y (financed by ANR)