INTERNSHIP PROPOSAL

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CNRS identification code: UMR7587

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

Photon thermalization in disordered scattering media for new light sources

Coupling quantum emitters to photonic cavities is a common way to control light-matter interaction and produce light sources operating in different regimes, from spontaneous emission in LEDs to stimulated emission in lasers. Multiple scattering in a disordered medium is another and apparently simple way to enhance the interaction between an ensemble of emitters immersed within the medium and the emitted light. When the size of the medium exceeds the scattering mean free path, photons undergo a diffusive random walk that increases the probability of absorption and emission by the fluorophores, thus mimicking the effect of a cavity. This idea led to the concept of random laser, that has been demonstrated in a large variety of configurations, from colloidal suspensions in a dye solution to infiltrated powders or white paints [1, 2]. Since photons are bosons, they can undergo Bose-Einstein condensation which is a phase transition characterized by a macroscopic population of the ground state of the system. A crucial step towards Bose-Einstein condensation is thermalization. While for massive particles, thermalization is the result of inter-particle collisions, for non-interacting photons the key mechanism is emission-absorption cycles of a reservoir of fluorescent molecules. Bose-Einstein condensation of photons in a cavity filled with dye molecules has been observed relatively recently [3], and came well after the condensation of atomic gases (1995) or polaritons in semiconductor microcavities (2002).

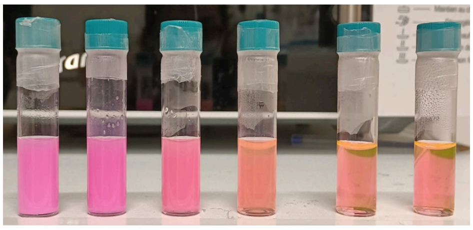

Figure: solution containing fluorescent dyes and scattering particles for different concentrations of scattering particles (higher on the left of the picture).

In this project we propose to study photon thermalization towards Bose-Einstein condensation in a solution of fluorescent emitters in which the cavity is replaced by a strongly scattering medium. Diffusion ensures that photons undergo an adequate number of absorption and emission cycles to thermalize with the dye solution. **The study will be performed theoretically, numerically and experimentally.** We will explore different regimes in which the light emitted by the fluorophores/scattering medium ensemble shows either a fluorescent spectrum or a thermalized spectrum or Bose-Einstein condensation. This will be achieved by changing the density of emitters and the properties of the scattering medium. Different kinds of fluorophores and scattering materials will also be considered in order to efficiently reach the thermalization regime. This paves the way to new affordable light sources based on easy-to-fabricate scattering materials.

References:

[1] H. Cao, Random Lasers: Development, Features and Applications, Opt. Photon. News 16, 24 (2005).
[2] D. S. Wiersma, The physics and applications of random lasers, Nat. Phys. 4, 359 (2008).
[3] J. Klaers, J. Schmitt, F. Vewinger, and M. Weitz, Bose–Einstein condensation of photons in an optical microcavity, Nature 468, 545 (2010).

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: YES