New thermalized light sources based on fluorescent scattering media

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The spectrum of the light emitted by a black body in thermal equilibrium at temperature T, such as the Sun or a light bulb, is determined by the temperature alone, as stated by Planck's and Wien's law. In such source, photons exhibit a vanishing chemical potential, meaning that their number is not conserved when the temperature of the black body is varied. **At Institut Langevin we have recently experimentally demonstrated that a different behavior can be observed for photons emitted by laser-pumped Rhodamine fluorescent molecules in a scattering medium** [1]: by promoting multiple absorption-emission cycles in such a system one ends up with a photon gas at thermal equilibrium with a defined number of photons. This equilibrium is characterized by the temperature of the dye solution, and by a chemical potential that depends on the population of the excited and fundamental molecular levels. Scattering disordered media offer several advantages with respect to other systems in which photon thermalization has been observed, such as cavities [2], in terms of scalability, versatility, and ease of fabrication.

The next step after this first proof of principle is to design the disordered scattering medium and the properties of the fluorophores to optimize the occurrence of photon thermalization.
At ESPCI PSL, the Institut Langevin and LPEM are seeking a motivated intern and PhD candidate to join an exciting ANR-funded collaborative project investigating photon thermalization in disordered scattering media.

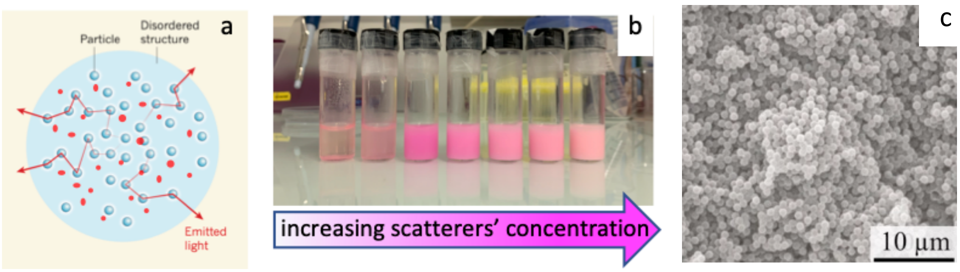

***Figure: a.** Principle of thermalization in fluorescent scattering disordered media. **b.** Samples containing fluorescent dyes and scattering particles studied for the first proof of principle. **c.** Correlated disorder scattering media.*

In the frame of the internship, the student will work at both LPEM to synthesize inorganic nanomaterials as scatterers or emitters with well controlled optical properties and at Institut Langevin to characterize the ability of the samples to generate thermalized light. The student will synthesize nanoparticles with well defined Mie resonances in order to structure the spectral properties of the scattering medium, and semiconductor quantum dots in order to optimize photon recycling. The scattering length and the fluorescence properties of the synthesized samples will be characterized at Institut Langevin using optical spectroscopy techniques already established and optimized for the observation of photon thermalization.

During the PhD thesis that will follow the internship, we will use the knowledge developed in nanoparticles synthesis and thermalization to develop innovative scattering materials with optimized disorder correlations. By shaping the disorder, we will act on the optical modes to control the spectral properties of the thermalized photon gas. By tuning the target spectral band with respect to the chemical potential of the photon gas, we will explore systems with defined spectral resonances. The final aim of the PhD thesis will be to reach the regime of Bose-Einstein condensation of photons [2], in which an optical mode of the disordered material is macroscopically populated.

We are accepting applications from students with different background and motivation, ranging from quantum optics and nanophotonics to physical-chemistry, and from fundamental research to applied sciences interests.
Possibility to go on with a PhD ? Yes. Starting date between January 1st and October 1st 2026
Funding secured: ANR project

References: [1] L. Soncin et al., in preparation (2025)[2] J. Klaers et al., Nature **468**, 545 (2010).