# Spécialité de Master « Optique, Matière, Paris »

*Stage de recherche (4 mois minimum, à partir de début mars)*

## Proposition de stage (ne pas dépasser 1 page)

*Date de la proposition : 4-6 mois*


**Responsable du stage** / *internship supervisor*:

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|---|---|---|---|
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**Nom du Laboratoire** / *laboratory name*: Institut Non Linéaire de Nice (INLN)

Code d'identification : UMR7335 Organisme : CNRS

Site Internet / *web site*: http://www.inln.cnrs.fr/activites/themesrecherche/atomes-froids

Adresse / *address:* 1362 Route des Lucioles, Sophia Antipolis, 06 560 Valbonne

Lieu du stage / *internship place*: Valbonne Sophia-Antipolis


**Titre du stage** / *internship title*: **Subradiance with on-site disorder**

Wave propagation in diffusive media is an important subject for numerous fields (medical imaging, acoustics, seismology, stellar physics,…). The experiments that we pursue in our team make use of an original medium: a cold-atom cloud. The peculiar properties of this diffusive medium (strong resonances, quantum internal structure of the scatterers, mechanical effects of light on the atoms, quantum effects…) give rise to a very rich physics. One of the subjects we are studying is **cooperative scattering**.

When a photon is sent onto an atomic ensemble, it interacts collectively with the $N$ atoms of the cloud and not simply with one of them. This results in measurable modifications in the scattering rate, the emission diagram or the temporal dynamics. We study these cooperative effects experimentally and theoretically. Recently, we managed to observe **subradiance** [1], and superradiance in the linear-optics regime [2]. We are now performing complementary experiments on subradiance in order to understand the influence of multiple scattering and of the atomic thermal motion.

The next step will be to add "on-site disorder" in the system, i.e., to change randomly the atomic resonant frequencies of each atoms. One idea to do so is to use the light-shift (AC Stark shift) induced by a 3D speckle pattern illuminating the atoms. There are two reasons to perform this experiment. First, it could be a way to enhance the relative weight of the subradiance states, which would make them easier to detect and to use for quantum-optics applications. Second, as suggested recently [3], it could induce a spatial localization of the subradiant modes with **phase transition induced by the disorder**, sharing similitudes with the celebrated Anderson localization.

The internship can be either **numerical or experimental**. If numerical, the goal will be to use the coupled-dipole model to test how on-site disorder can enhance subradiance, and to determine what experimental signature to look at for detecting the localization effect. If experimental, the goal will be to design, set up and characterize the optical system to produce the 3D speckle pattern, then to set it up on the cold-atoms apparatus and, if time allows it, to participate to a first series of experiments on subradiance with on-site disorder.

References:


[1] **Subradiance in a large cloud of cold atoms**, W. Guerin, M. O. Araújo, and R. Kaiser, Phys. Rev. Lett. **116**, 083601 (2016).
[2] **Superradiance in a large and dilute cloud of cold atoms in the linear-optics regime**, M. O. Araújo, I. Krešić, R. Kaiser, and W. Guerin, Phys. Rev. Lett. **117**, 073002 (2016).
[3] **Subradiance localization in the open 3D Anderson-Dicke model**, A. Biella, F. Borgonovi, R. Kaiser, and G. L. Celardo, Europhys. Lett. **103**, 57009 (2013).


**Ce stage pourra-t-il se prolonger en thèse ?** *Possibility of a PhD* **? : Yes**

**Si oui, financement de thèse envisagé/** *financial support for the PhD*: **To be discussed**

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| Lumière, Matière, Interactions | **X** | Lasers, Optique, Matière | **X** |