# Spécialité de Master « Optique, Matière, Paris »

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

## Proposition de stage

*Date de la proposition :*


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

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|---|---|---|---|
| Nom / *name*: | SANCHEZ-PALENCIA | Prénom/ *first name* : | Laurent |
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**Nom du Laboratoire** / *laboratory name*: Laboratoire Charles Fabry

Code d'identification : UMR8501 Organisme : CNRS, Institut d'Optique, Univ Paris-Saclay
Site Internet / *web site*: http://www.uquantmat.fr
Adresse / *address:* 2 avenue Augustin Fresnel, F-91120 Palaiseau
Lieu du stage / *internship place*: Palaiseau


**Titre du stage** / *internship title*: **Far-from-Equilibrium Dynamics in Utracold Quantum Systems**


Résumé / *summary*

How does a strongly-correlated quantum system evolves when driven out of equilibrium? This question is central, not only from a basic point of view to understand the dynamics of quantum systems, but also from a practical point of view in the growing field of quantum communications. It is, however, still a very debated question, which stimulates a very strong interest in a wide community.

In this context, ultracold atoms are particularly interesting because it is now possible to investigate many far-from-equilibrium properties of these ystems thanks to accurate time-dependent control of the physical parameters [1,2]. In practice, one can prepare the gas in some initial state, then abruptly change one or several parameters, and observe the subsequent dynamics. The gas develops correlations that spread over in the system. In the simplest cases, in particular when the interactions are short range, Lieb and Robinson have shown that there exists a limit to the propagation velocity of correlations, creating a cone (usually named the « light cone ») in which the correlations are bounded [3,4].

The aim of the internship and thesis will be to theoretically investigate the propagation of correlations beyond the Lieb-Robinson limit. We will study the behavior of correlations in the limit of strong interactions, relevant to the most modern experiments on ultracold atoms. We will focus on novel situations where the Lieb-Robinson theorem breaks down, for instance in the presence of long-range interactions, which are relevant to experiments on molecular condensates or ion systems for instance. These fundamental issues will be addressed from a theoretical point of view, using the most modern *N*-body approaches, both analytical and numerical, as developed in previous works [5,6].



[1] J. Eisert, M. Friesdorf & C. Gogolin, Nature Phys. **11**, 124-130 (2015).
[2] M. Cheneau *et al.*, Nature **481**, 484-487 (2012).
[3] E.H. Lieb & D.W. Robinson, Comm. Math. Phys. **28**, 251-257 (1972).
[4] P. Calabrese & J. Cardy, Phys. Rev. Lett. **96**, 136801 (2006).
[5] G. Carleo, F. Becca, L. Sanchez-Palencia, S. Sorella & F. Michele, Phys. Rev. A **89**, 031602(R) (2014).
[6] L. Cevolani, G. Carleo & L. Sanchez-Palencia, Phys. Rev. A **92**, 041603(R) (2015).


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

**Si oui, financement de thèse envisagé/** *financial support for the PhD***: Nous consulter / Consult us**

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|---|---|---|---|
| Lumière, Matière, Interactions | **YES** | Lasers, Optique, Matière | **YES** |