# 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*: Aurélien Perrin

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|---|---|---|---|
| Nom / *name*: | Perrin | Prénom/ *first name* : | Aurélien |
| Tél : | 01 49 40 32 03 | Fax : | 01 49 40 32 00 |
| Courriel / *mail*: | Aurelien.perrin@univ-paris13.fr | | |

**Nom du Laboratoire** / *laboratory name*:

Code d'identification : UMR7538 Organisme : CNRS / Paris 13

Site Internet / *web site*: www-lpl.univ-paris13.fr/bec

Adresse / *address:* Institut Galilée, 99 avenue J.-B. Clément, 93 430 Villetaneuse

Lieu du stage / *internship place*: Laboratoire de physique des lasers


**Titre du stage** / *internship title*: Magnetic transport of ultra-cold atoms


**Résumé / *summary***

Cooling atoms to ultracold temperatures allows one to get sensitive to their quantum nature. In particular, for dilute bosonic gases below a certain threshold, atoms tend to accumulate in a single quantum state, giving rise to the Bose-Einstein condensation phenomena. The properties of such systems have been extensively studied in the past decade. Nowadays the high degree of control achievable over these gases permits to use them as quantum simulators in order to explore the physics of extremely complex systems for which experiments are often far from reach: condensed matter, cosmology …

Our group is currently building a novel cold atom setup aiming at the study of nonequilibrium dynamics. In particular we are interested in the Kibble-Zurek mechanisms, which have been used as a model to describe the physics of the early universe, as it started to expand. Ultra-cold gases undergoing a rapid quench to a quantum phase transition serve as a model for this system. We will explore the influence of the system dimensionality (1D, 2D) on these phenomena. Observing the relaxation toward equilibrium should also help answering many questions in this field, most of them being still open.

The status of the experiment is as follows: near a billion sodium atoms are currently loaded in a magneto-optical trap from a Zeeman slower. The next step consists in bringing the atoms in the main vacuum chamber, where they will be cooled down to the Bose-Einstein condensation threshold. This will be achieved with a magnetic transport, allowing the displacement of the trapped cold atoms over about 60 cm. The mechanical part of the transport has already been built and installed: it relies on the use of about 40 magnetic coils. Continuously modifying the current flowing into these coils will allow us to carefully move the magnetic quadrupole where the atoms are trapped.

The main aim of the internship consists in demonstrating and optimizing the magnetic transport of the atomic cloud, in order to minimize the atomic losses, the heating of the sample and the transport duration. We will in particular study the possibility of non-adiabatic transport with optimal control procedures, where the temperature of the atoms remains constant. This should allow us to considerably lower the duration of the transport, increasing in turn the duty cycle of the experiment. This step will require numerical simulations relying on molecular dynamics algorithms.

Once the magnetic transport will be working on a regular basis, the internship will focus on the loading of an atom chip from the magnetic trap. It consists of microfabricated gold wires deposited at a semiconductor surface allowing the creation of magnetic microtrap of diverse geometries.


**Methods and techniques**: Most of the internship will be experimental, involving electronics, programming and absorption imaging analysis. Molecular dynamics simulation will rely on an already available Matlab algorithm that could be optimized.

**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***:**

Ecole doctorale Galilée

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

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