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 : 09/10/18

Responsable du stage / *internship supervisor*:			
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Nom du Laboratoire / *laboratory name*: LP2N (Laboratoire de photonique, numérique et nanosciences)			
Code d'identification :UMR5298		Organisme : Institut d'Optique	
Site Internet / *web site*: https://www.coldatomsbordeaux.org/aufrons			
Adresse / *address:* Rue Francois Mitterrand, 33400 Talence			
Lieu du stage / *internship place*: Talence - Bordeaux (33)			

Titre du stage / *internship title*: **Adiabatic transport and laser cooling of atoms in the near field of surfaces.**

Résumé / summary

The recent years have seen tremendous progress in the realization and the study of artificial quantum materials using ultracold atomic gases. By trapping fermionic or bosonic atoms in artificial crystals of light (so-called optical lattices), fundamental condensed matter phenomena traditionally only observed in solid-state materials have become accessible in a different and highly controlled environment. Experiments are now reaching up the level where these quantum gases start to be considered as true "quantum simulators" for tackling a broad range of open physics problems, including among others quantum magnetism and topological insulators.

The long-term objective of our project is to explore quantum transport in sub-wavelength lattices, and how it is influenced by lattice geometry, band structure topology, disorder or interactions. To this end, we are currently building a novel experimental apparatus specifically adapted to the production of ultra-cold Rubidium gaz trapped in the vicinity of nano-structured surfaces. A crucial challenge to face in the manipulation of atoms in the vicinity of surfaces are the quantum force (Casimir Polder interaction) that attract atom on the surface. These forces are very strong and have prevented so far to control atoms in the close vicinity of surfaces.

In our team, we have developed an innovative method capable to counterbalance the Casimir attraction and that is well adapted to transport high atom number clouds to the near field of surfaces. This method includes two steps that have recently been numerically validated: a so called surface rotation transport (SRT from 5 µm to 500 nm) and a doubly dressed state trap (DDS trap from 500 nm to 50 nm). In this internship, the student will work on specific aspects related to the implementation of both the SRT and the DDS trapping. On the SRT side, the work will include some prior simple numerical simulation to familiarize with the concepts involved in our method. The student will then focus on the experimental implementation of the precise locking of the surface rotation trajectory. The position and speed of the mirror will be acquired using a quadrant photodiode and the feedback loop will take advantage of FPGA (fast digital electronics) programming for which we have prior expertise in my team that will be taught to the student. On the DDS trap side, the student will be involved in a promising theoretical work to realize a situation for efficient lattice cooling to the ground state. This situation is achieved by using the doubly dressed state method to tune the trapping frequencies of the ground and excited state in the novel regime of optically resolved Raman sideband cooling. In this second part of the internship the student will use the master equation formalism to evaluate the cooling efficiency of the proposed method.

The master student will work in a team composed of 1 PhD, 1 PostDoc and 2 researchers.
The subject of the internship will allow the student to progress on theoretical (lasers, light-matter interaction, master equation) and experimental knowledge (laser optics, mechanics, analog and digital (FPGA) locking electronics, automatism, programming, data analysis etc…). This master internship could lead to a PhD thesis (grant secured through the ANR). The PhD thesis will involve both theoretical and experimental work on hybrid quantum systems of atoms and nano-structured surfaces.

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

Si oui, financement de thèse envisagé/ *financial support for the PhD*: **ANR (obtenu)**

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