MASTER 2 RECHERCHE PHYSIQUE

PROPOSITION DE STAGE

TITRE	**Ultra-stable transfer cavity for sub-wavelength imaging.**
LABORATOIRE	**Laboratoire Photonique Numerique et Nanosciences (LP2N) – Institut d'Optique d'Aquitaine (IOA)**
RESPONSABLE(S)	**Bernon Simon**

CONTACT	
Téléphone	**e-mail**
+33 5 57 01 72 33	simon.bernon@institutoptique.fr

RESUME DU SUJET DE STAGE

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 or superfluidity.

The long-term objective of our project is to explore quantum transport in this setting, 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 ultracold bosonic and fermionic potassium gases with adjustable interactions. The project that we propose will in particular concentrate on the physics of two dimensional electron gaz of solid state systems by studying the transport of cold fermionic atoms trapped in a two dimensional optical lattice. This domain of fermionic quantum simulators lay in an extremely competitive international background. This project will detach from this competition by developing a new and original approach. The classical approach of cold atom based quantum simulators consists in trapping atoms in the lattice potential generated by interfering counter-propagating laser beams. Being a far field method, this classical approach is fundamentally limited by optical diffraction and the lattice spacing is thus limited to $\lambda/2$ where λ is the optical wavelength. In this project, we will step aside from the international competition by developing a new near-field system. In this system, the atoms will be trapped close to a nano-structured surface trap that will enable the study of 2D gaz in sub-wavelength potentials.

To study atoms placed in a sub-wavelength potential, one requires sub-wavelength imaging techniques. We have developed a general scheme for such innovative imaging that rely on quantum engineering the excited state of a system. To best work, our experimental procedure requires to stabilize in frequency a trapping laser at 1064 nm and a “shaping” laser at 1529 nm. These two frequencies being so far from each other, they cannot be directly referenced to each other and a transfer cavity is required. In this context, the work of the student will be to design and set up a very stable transfer cavity that will be resonant to both 1064 nm and 1529 nm. He will then use the cavity to stabilize the frequency difference of the two lasers. With such transfer cavity the sub-wavelength imaging scheme should reach nano-metric resolution.

Depending on the intern and the financial opportunities, this master thesis could lead to a PhD thesis in the team.