Spécialité de Master « Optique, Matière, Plasmas »

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

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 03/10/2013

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Nom du Laboratoire / *laboratory name*: **ICFO - The Institute of Photonic Sciences**

Code d'identification : Organisme : ICFO/UPC-BarcelonaTech

Site Internet / *web site*: www.qge.icfo.es (groupe de recherche) ; www.icfo.eu (laboratoire)

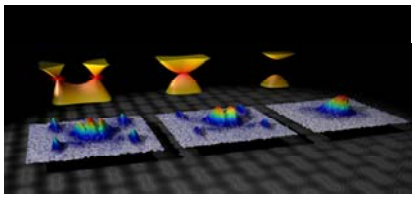
Adresse / *address:* Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Espagne

Lieu du stage / *internship place*: ICFO-The Institute of Photonic Sciences, Ultracold Quantum Gases group

Titre du stage / *internship title*: **Ultra-cold fermions in optical lattices**

Résumé / *summary*

In recent years ultra-cold atomic gases have emerged as a novel platform for the study of quantum many-body systems, giving access to phenomena originally studied in condensed-matter in a novel and highly controlled setting [1]. In this context, degenerate Fermi gases trapped in the potential created by interfering laser beams are a particularly clear example. By replacing the electrons by atoms, and the crystalline structure of solids by an optical lattice, these systems indeed provide the cleanest quantum « materials » that can be studied in the laboratory [2]. Fermions in optical lattices therefore appear as ideal test systems for studying the physics of strongly correlated materials. Indeed, after the first observation of a fermionic Mott insulator [3], the experiments are now starting to reach the regime in which the spin degree of freedom orders as well [4], opening the possibility to study quantum magnetism in the near future. Furthermore, these systems also offer the intriguing opportunity of reaching extreme parameter regimes that are not accessible in the solid-state context.



An example of extreme parameters that can be easily realized in cold atom systems : fermionic potassium atoms loaded in a tunable honeycomb lattice mimic the physics of graphene, but can also access a regime where the two Dirac points merge, annihilating each other [5].

Our group is currently setting-up at ICFO a new experimental apparatus specifically adapted to the production of ultracold potassium Bose and Fermi gases in complex optical lattices, and to their characterization using high-resolution radio-frequency spectroscopy. During the internship, the student will participate on the construction of the experimental apparatus and will also analyze the possibility of implementing a fluorescence imaging method that gives access to the momentum distribution of the cloud with single-atom resolution [6]. After attaining the quantum degenerate regime, the subsequent PhD thesis will focus on the study and characterization of magnetic phases, and the quantum phase transitions appearing between them when the lattice geometry is modified.

[1] I. Bloch, J. Dalibard, and S. Nascimbène, Nature Physics **8**, 267 (2012).
[2] T. Esslinger, Annu. Rev. Condens. Mater. Phys. **1**, 129 (2010).
[3] R. Joerdens, N. Strohmaier, K. Guenter, H. Moritz and T. Esslinger, Nature **455**, 204 (2008).
[4] D. Greif, T. Uehlinger, G. Jotzu, L. Tarruell, and T. Esslinger, Science **340**, 1307 (2013)
[5] L. Tarruell, D. Greif, T. Uehlinger, G. Jotzu and T. Esslinger, Nature **483**, 302 (2012),
[6] R. Bücker *et al.*, New J.Phys. **11**, 103039 (2009).

Toutes les rubriques ci-dessous doivent obligatoirement être remplies

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***: bourse ICFO**

Lasers, Optique, Matière	**X**	Lumière, Matière : Mesures Extrêmes	**X**
Plasmas : de l'espace au laboratoire			

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