Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

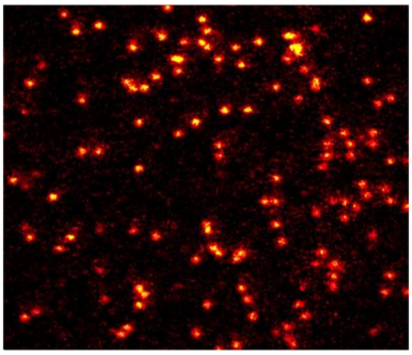
(One page maximum)

Laboratory name: Laboratoire Kastler Brossel
CNRS identification code: UMR8552
Internship director'surname: Tarik Yefsah
e-mail: tarik.yefsah@lkb.ens.fr Phone number: 01 44 32 38 03
Web page: http://www.lkb.upmc.fr/ultracoldfermigases
Internship location: ENS Physics Department

Thesis possibility after internship: **YES**
Funding: **To be applied for** If YES, which type of funding:

Quantum Simulation with ultracold Fermi gases

Our research group focuses on the understanding of low temperature strongly-correlated Fermi gases in the BEC-BCS crossover, combining theoretical and experimental expertise. Strongly-correlated fermions are ubiquitous in nature, from the quark-gluon plasma of the early universe to neutron stars found in the outer space, they lie as well at the heart of many modern materials such as high-temperature superconductors, colossal magneto-resistance devices or graphene. While being a pressing issue covering a wide fundamental and technological scope, the understanding of strongly-correlated fermions constitutes a serious challenge of modern physics, which is often hindered by the complexity of the host systems themselves.



Potassium 40 atoms pinned in an optical lattice and exposed to cooling laser beams. The atoms absorb and re-emit photons which are collected via a high resolution objective. Each bright spot signals the presence of an atom with a fidelity > 99.6%. This method has also been demonstrated for ^{6}Li. *Courtesy of M. Zwierlein MIT*

The contribution of ultracold atom experiments in this outstanding quest resides in the ability to set fermions in a well-characterized environment. In these systems, one can add a single ingredient at a time (spin mixture, interactions, lattice, etc) with a high degree of control, allowing for an incremental complexity, which represents an ideal playground for a direct comparison to many-body theories. So far, the experiments performed with ultracold Fermi gases could only probe the system via measurements of the average density. Our new experiment aims at probing such systems at the single-atom level, giving a direct access to their microscopic properties (see figure).

The aim of the internship will be to realize tailored optical potentials for ultracold lithium atoms. This project requires both theoretical and experimental skills (light-matter interaction, optics, etc.). This project, which is expected to be followed by a PhD thesis, is one of the key steps towards the study of homogeneous Fermi gases with single atom resolution.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: YES