Laboratoire Kastler Brossel
Physique quantique et applications

Quantum Simulation with Ultracold Fermi gases

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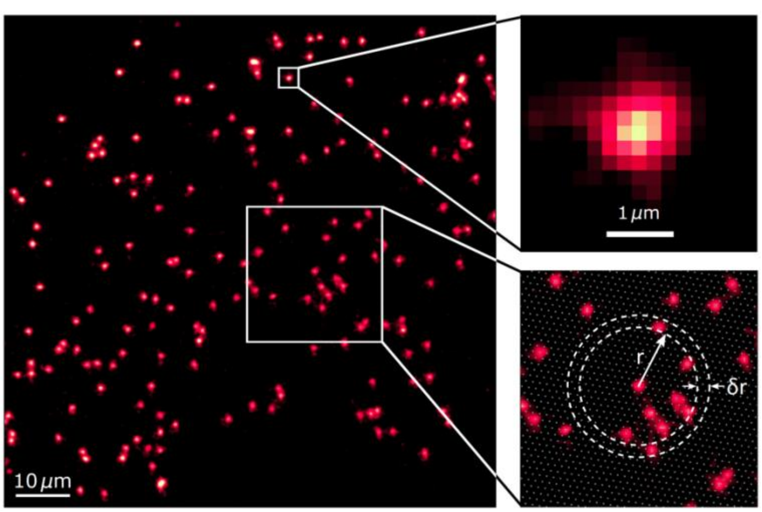
Internship location: ENS Physics Department
Thesis possibility after internship: YES

From the promise of exponentially faster computers, new ways to transmit and store information, and vastly improved sensing capabilities, quantum science has become an extremely active area of research, providing a wide range of platforms, each with its particular strength. With **quantum gases of ultracold atoms**, experiments have had tremendous success in tackling quantum many-body problems, where unexpected and qualitatively new phenomena can emerge. These problems are notoriously complex owing to the large number of interacting particles, strong interactions, disorder, or nonlinear dynamics. This is the general context of this internship work, which will focus on atom-based quantum simulation of strongly-interacting fermionic quantum matter.

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.

The contribution of ultracold gas 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.

Our group aims at understanding the behavior of strongly-interacting fermionic systems using an atom-based quantum simulator featuring single-atom imaging and manipulation capabilities. During this internship, you will take your first steps in the team by contributing with an experimental project (several options) with the perspective to join us as a PhD student in the Fall 2024.



Single-atom imaging of an ultracold ^{6}Li cloud. The quantum gas microscope is a powerful tool until now devoted to the study of lattice physics. Our experiment is designed to apply it to continuous gases: after preparing the cloud in a given state of matter, the atoms are suddenly pinned in a deep optical lattice and exposed to near-resonant light. On this image, each bright spot indicates the presence of an atom. The bottom-right panel illustrates how spatial correlation functions are readily accessible.