Master 2 "Photonics, Complex and Quantum Systems (PhoCQS)": Research Training 2025-2026
Master 2 "Matter Molecules and their Environment (MME)": Research Training 2025-2026

Appel à sujet de stage recherche / Call for research training subject

Laboratory: PhLAM

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Topic: Ultracold Atoms

Master 2: select the master and the most appropriate option

☑ Master 2 PhoCQS (GP-IKS)	□ Master 2 MME (GP-SCP)
☑ Option Complex and Quantum Systems	□ Option Condensed Matter
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Quantum transport in a driven potassium 1D Bose-Einstein condensate

Quantum transport phenomena span a large spectrum of different physical systems –from electronic, acoustic and photonic systems to ultracold atomic gases– where phase coherence properties of classical or quantum matter waves play a crucial role. The interplay between quantum interferences, particle interactions, and inherent disorder (imperfections) in the medium plays a key role, giving rise to a wide variety of transport behaviors. Atomic Bose-Einstein condensates (BECs) stand out as test platforms in which one can study these effects in a particularly clean and well-controlled environment.

In this context, our group studies a dynamical system consisting of a potassium Bose-Einstein condensate being submitted to a periodically-driven optical potential. In a non-interacting picture, this gives rise to a particular type of wave localization in momentum space, also called 'dynamical localization' [1,2]. However, when the system is confined in one spatial dimension (1D) and interparticle interactions are turned on, nontrivial quantum correlations between atoms will drastically change the properties of the system. For instance, in 1D and in the limit of strong repulsive interactions, the bosonic atoms repel each other and behave similarly to fermions. In this limit, a new phenomenon has been recently observed [3] and named 'many body dynamical localization'. However,

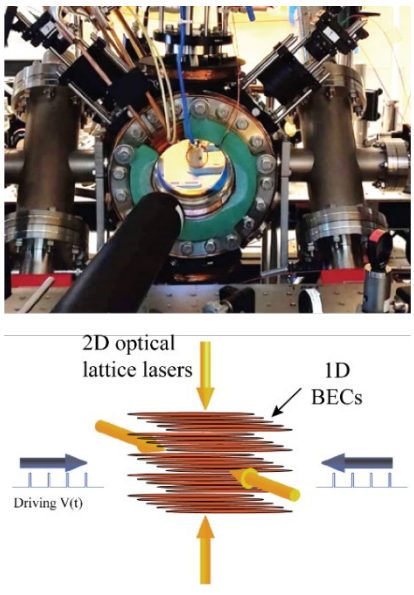

Figure 1 (top) Potassium BEC experiment. (bottom) Schematic of the 2D optical lattice

many fundamental aspects of this phenomenon still remain poorly understood.

The goal of the M2 internship is to implement a tightly-confining 2D optical lattice in the potassium BEC experiment. This lattice will separate the BEC in a series of very thin ‘atomic wires’ and will ‘freeze’ the transverse degrees of freedom of the BEC, constraining its dynamics to become effectively 1D. In addition, applying a well-controlled and stable magnetic field will allow to tune the interatomic interactions between potassium atoms (using the so-called magnetic ‘Feshbach resonances’). These new tools will allow to study the 1D transport properties of the driven potassium BEC and better understand the behavior of correlated quantum many-body dynamical systems.

The internship will lead to a PhD project, funded by an ongoing ANR project.

Key words: Ultracold quantum gases, Quantum transport, 1D quantum gases, Quantum simulations