INTERNSHIP PROPOSAL

Laboratory name: LPENS
CNRS identification code:
Internship director'surname: Xavier Leyronas & Frédéric Chevy
e-mail: xavier.leyronas@phys.ens.fr frederic.chevy@phys.ens.fr
Web page: https://www.ultracoldmatter.org/home
Internship location: ENS, 24 rue Lhomond 75005 Paris

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

AC Transport in ultracold quantum materials

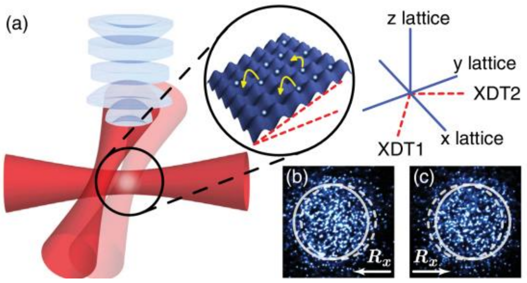

Figure 1: sketch of UToronto's experiment. Cold atoms are confined in an optical lattice and shaken by a moving laser beam. (a). Quantum gas microscopy at single atom resolution gives access to the full atomic distribution and allows for a determination of the center-of-mass response of the cloud (b,c).

Measuring conductivity has proven to be a powerful discovery tool for new physics in materials. However, a first-principles connection between macroscopic functional properties and their microscopic quantum origins is challenging due to the non-equilibrium nature of transport and by the intricate structure of materials. The challenge is one of classical computation: even when candidate Hamiltonians are well known, cutting-edge computational methods cannot time-evolve a fermionic many-body wave function without approximations.

Quantum simulations with ultracold atoms offer the prospect to bridge this gap, by comparing emergent phenomena in a simpler system to ab-initio theory. The power of this approach lies in the ability to control initial conditions, observe dynamics, and tune elements of the underlying Hamiltonian. Pioneering results were obtained by a collaboration between LPENS and the group of J. Thywissen's at University of Toronto by measuring the response of a cloud of ultracold atoms trapped in an optical to an external drive (see Fig. 1 from [1]). This seminal work was restricted to a dilute and weakly interacting vapor and the internship and the following thesis project will extend its scope by studying theoretically the properties of AC conductivity in the strongly interacting regime. This problem will be addressed using different and complementary theoretical approaches, from kinetic theory to diagrammatic methods.

[1] *Optical conductivity of a quantum gas*, R. Anderson, F. Wang, P. Xu, V. Venu, S. Trotzky, F. Chevy, J. H. Thywissen, Phys. Rev. Lett. **122**, 153602 (2019);

.

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

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES