Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: LCAR
CNRS identification code: UMR5589
Internship director'surname: David Guéry-Odelin
e-mail: dgo@irsamc.ups-tlse.fr Phone number: 05 61 55 83 21
Web page: https://www.quantumengineering-tlse.org
Internship location: Toulouse

Thesis possibility after internship: **YES**
Funding: YES If YES, which type of funding: Région/Université

Quantum simulation involving delocalized Floquet states

Our group is investigating quantum simulations with ultracold atoms in time-modulated lattices. In a recent publication [1,2], we have demonstrated experimentally how quantum transport can be mediated by a delocalized state with the study of an amplitude-modulated quantum pendulum. For this purpose, we have placed a Bose Einstein condensate in a time-dependent 1D optical lattice in a parameter range for which the corresponding classical phase space is partially chaotic, i.e. made of stable islands surrounded by a chaotic sea. The chaotic sea encapsulates delocalized Floquet states (DFS) that play a key role in the coherent quantum transport between islands, and explain the resonances that we have observed in the transport.

The first goal of the Master internship consists in demonstrating the long range character of the coherent coupling between islands mediated by a DFS, in a regime similar to [1,2]. We have theoretically investigated several experimental techniques that can be envisioned to extract quantitatively the coupling coefficients between islands depending on their relative distance. This work opens very interesting perspectives for quantum simulation, as it allows to access models involving long-range hoppings, inaccessible so far.

The second goal of our research (to be studied during the PhD following the internship) is to investigate the role of interactions in DFS assisted transport. This question is related to decoherence in quantum mechanics. A solution to account for interactions is a description by a Bose-Hubbard-like model, currently under investigation by our collaborators from the LPT (Laboratory of Theoretical Physics) in Toulouse. The close comparison between experimental results and the theory will provide a testbed for quantum simulation. We also plan to study the quantum transport mediated by delocalized states in the strongly interacting regime. This is so far an untouched domain, which is accessible on our experimental setup with extra optical lattices and appropriate time-dependent controls.

Références bibliographiques

[1] *Chaos-assisted tunneling resonances in a synthetic Floquet superlattice,* M. Arnal, *et al.*, Science Advances **6**, eabc4886 (2020).
[2] Actualités CNRS (https://inp.cnrs.fr/fr/cnrsinfo/le-chaos-pour-controler-des-atomes-ultrafroids)

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

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