MASTER 2 INTERNSHIP PROPOSAL

Laboratory name: **LCAR, CNRS Université Paul Sabatier, Toulouse**
CNRS identification code: **UMR 5589**
Internship director'surname: **David Guéry-Odelin**
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Internship location: **Toulouse**

Thesis possibility after internship: **high probably**
Funding: **YES for the Internship. Funding has been requested for the PhD thesis**

Quantum simulation based on Floquet engineering

A fruitful technique for performing quantum simulation is to drive a quantum system periodically over time. The steering modifies the long-term dynamics and can be designed to generate a wide range of non-trivial effective energy bands and gauge structures in quantum matter systems. From a classical point of view, steering generates a chaotic phase space with specific features such as dynamically stable islands immersed in a chaotic sea.

Our team specializes in quantum simulartion, quantum control [1] and in the production and study of such Floquet systems [2,3], in a setup using a Bose Einstein condensate in a time-dependent lattice potential. We have developed expertise in interpreting and using the link between the pictures provided by classical chaos theory and their quantum counterpart [2,3].

We offer an internship dedicated to the investigation of a new class of quantum simulator based on Floquet engineering. We will study the quantum properties of different effective systems of connected sites to emulate some models originally developed in condensed matter, such as the well-known SSH model. The effective energy of each site, and the tunneling rate between them can be controlled by an appropriate modulation. We plan to study edge states in finite chains, the topological edge states when two chains are connected in the presence of a defect, as well as transport effects and quantum localization when controlled disorder is added to the system. The PhD that we propose after the internship will investigate the generalization of those ideas at 2 and 3 dimensions, and extend the possibilities by using the atomic internal states.

[1] *Quantum state control of a Bose-Einstein condensate in an optical lattice*
N. Dupont, G. Chatelain, L. Gabardos, M. Arnal, J. Billy, B. Peaudecerf, D. Sugny, D. Guéry-Odelin, PRX Quantum **2**, 040303 (2021).

[2] *Chaos-assisted tunneling resonances in a synthetic Floquet superlattice*
M. Arnal, G. Chatelain, M. Martinez, N. Dupont, O. Giraud, D. Ullmo, B. Georgeot, G. Lemarié, J. Billy and D. Guéry-Odelin, Science Advances **6**, eabc4486 (2020).

[3] *A regular Hamiltonian halting ratchet for matter wave transport*
N. Dupont, L. Gabardos, F. Arrouas, N. Ombredane, J. Billy, B. Peaudecerf, D. Guéry-Odelin
Phys. Rev. Lett. **131**, 133401 (2023). Editors' suggestion. Featured in Physics.