INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique de l'ENS (LPENS)
CNRS identification code: UMR 8023
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Web page: https://www.lpens.ens.psl.eu/recherche/quant/equipe-21/
Internship location: Hybrid Quantum Circuit Group (LPENS)

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Probing electronic states of a synthetic 1D chain with transport and cQED

A chain with modulated tunnel couplings realizes the Su–Schrieffer–Heeger (SSH) model, where topological modes appear in the band gap, localized at the edges. More generally, 1D chain models such as the Peierls transition, Kronig–Penney, or Tamm–Shockley, have long been used to illustrate how spatial modulation of the electrostatic potential opens band gaps and supports edge states. Beyond fundamental interest, engineering band gaps is appealing for quantum technologies, as it offers protection of fragile quantum states against decoherence by suppressing unwanted electronic excitations.

Recently, we have demonstrated the electrical control of such an electronic band gap induced in an ultra-clean carbon nanotube suspended over an array of 15 gate electrodes[1]. By applying an alternating electrostatic potential modulation at the carbon nanotube, we demonstrated the opening of a band gap up to a substantial value of 25meV, observed from transport measurement of the differential conductance across the system. An important aspect of our device approach is the possibility to tune continuously the modulation of the system in a simple manner.

The proposed internship, and following PhD, aims at pushing these recent results further to additionally probe the system with microwave photons in a mesoscopic QED architecture[2] already in place. The goal is to evidence the existence of edge states in the chain. For this, the candidate will exploit a newly demonstrated mQED readout technique developed in the team, which exploits dipole radiation in the cavity, parametrically activated by rf-gates at the edge of the chain[3]. Further directions include the possibility to emulate the SSH chain.
The candidate will benefit from the interaction with all members of the group and of the fruitful partnership we have with the startup C12.

The candidate should have a strong theoretical background in quantum and condensed matter physics, a strong interest in nano-devices and complex microwave techniques.

1. Craquelin, J. *et al.*, submitted (2025).
2. Cottet, A. *et al.*, J. Phys. Condens. Matter **29**, 433002 (2017).
3. Jarjat, L. *et al.*, submitted (2025).

Targert : ICFP Quantum Physics & Condensed Matter Physics; Quantum Engineering