INTERNSHIP PROPOSAL

Laboratory name: Lab. Physique ENS (LPENS)
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Web page: https://www.lpens.ens.psl.eu/recherche/quant/nano-thz/
Internship location: LPENS, 24 rue Lhomond, 75005 Paris cedex

Thesis possibility after internship: YES
Funding: Doctoral School

THz quantum devices based on graphene quantum dots coupled to a resonator

The emerging field of quantum technologies promises unprecedented advances in areas such as sensing, high-performance computing, simulation, cryptography, and metrology. These technologies have been so far implemented predominantly in the microwave and optical regimes and have an untapped potential in the terahertz (THz) spectral range. Exploiting this frequency domain could have a number of benefits, including superior wireless communication security through quantum cryptography, and increase the operating temperature of solid-state qubits, thus potentially overcoming existing scalability issues. Despite these prospects, THz quantum systems are fairly unexplored due to the relative immaturity of THz technology compared to microwave and optical counterparts.

Our group has recently demonstrated that hBN/graphene heterostructures [1] and graphene quantum dots are promising material systems for THz quantum technologies. For instance, single GQD exhibits remarkable sensitivity in detecting THz photons [2] and possess a large THz electric dipole [3]. Also, our group has developed original THz resonators to control the light-matter interaction from weak to ultra-strong coupling regime. These include THz Tamm cavities with a high-quality factor (>200) [4] and hybrid resonators based on a Tamm cavity strongly coupled to LC resonators that have made it possible to achieve both high Q and low V [5].

The aim of the internship is to explore novel THz quantum devices based on graphene quantum dots coupled to a THz resonator under different coupling regimes, from weak to ultra-strong. The candidate will participate to the nanofabrication of the quantum devices and probe their quantum response under coherent THz illumination at low temperature (1.5 K). The candidate will determine the quantum efficiency enhancement provided by the THz resonators and study the intensity and photon energy dependence of the THz photoresponse.
This internship may be pursued by a thesis. Further developments in the PhD project will leverage these THz quantum devices to generate and detect non-classical states of THz light.

[1] P. Huang *et al.* Nature Communications 11, 803 (2020)
[2] E. Riccardi *et al.* Nano Letters 20, 5408 (2020)
[3] S. Messelot *et al.* Physical Review Research 4, L012018 (2022)
[4] S. Messelot *et al.* ACS Photonics, 7, 2906 (2020)
[5] S. Messelot *et al.* Photonics Research, 11, 1203 (2023)

Methods and techniques: Nanofabrication, Low temperature phototransport measurements, THz sources, Design of THz resonator and cavity, Matlab/Python**.**

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