

Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de Physique de l'Ecole Normale Supérieure
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Internship location: LPENS, 24 rue Lhomond, 75005 Paris

Thesis possibility after internship: YES
Funding: YES Funding: Ministerial funding:

2D materials coupled terahertz Tamm cavity

Terahertz (THz) radiation, which lies typically between 0.1 to 10 THz, is extremely appealing for fundamental research as well as for a large number of applications, including astrophysics and atmospheric science. Enhancing and controlling the interaction of THz light with various material systems using THz resonators are of paramount importance for the development of advanced THz devices and for fundamental studies of cavity quantum electrodynamics.

Our group has recently demonstrated an original optical resonator based on Tamm modes for the THz spectral range [1,2] that exhibits a high-quality factor and a fine-tuning of the mode frequency (over a 250 GHz range). These THz Tamm cavities are therefore very attractive as basic building blocks of lasers, for the development of advanced THz optoelectronic devices and for THz cavity quantum electrodynamics in nanostructures.

The aim of the internship is to explore new schemes of Tamm cavities to achieve both high quality factor and also a sub-wavelength modal volume. The candidate will theoretically investigate the mode properties of these new cavity designs (resonance, quality factor, modal volume) at THz frequencies [3,4]. The coupling of 2D materials such as graphene to these cavity modes will be also studied. The candidate will further study experimentally these THz cavities and their coupling to 2D materials using advanced THz spectroscopy experiments.

This internship may be pursued by a thesis. Further developments in the PhD project include the development of a graphene-based THz laser and the study of the strong coupling regime by inserting 2D material nanostructures in THz Tamm cavities.

[1] S. Messelot, C. Symonds, J. Bellessa, J. Tignon, S. Dhillon, J.-B. Brubach, P. Roy and J. Mangeney, *ACS Photonics*, 7, 10, 2906 (2020)

[2] Brevet PCT N° PCT/EP2020/059572 (2019), 072051 WO RCA (2020)

[3] E. Riccardi, S. Massabeau, F. Valmorra, S. Messelot, M. Rosticher, J. Tignon, K. Watanabe, T. Taniguchi, M. Delbecq, S. Dhillon, R. Ferreira, S. Balibar, T. Kontos, and J. Mangeney, *Nano Lett.* 20, 7, 5408 (2020)

[4] P. Huang, E. Riccardi, S. Messelot, H. Graef, F. Valmorra, J. Tignon, T. Taniguchi, K. Watanabe, S. Dhillon, B. Plaçais, R. Ferreira & J. Mangeney, *Nature Communications*, 11, 863 (2020)

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