Laboratoire des solides irradiés
CEA/DRF/IRAMIS-CNRS-Ecole Polytechnique-IPParis
91128 Palaiseau, France

Fully funded PhD position available

Contract duration: 36 months from October 2024
Contacts : Luca Perfetti, luca.perfetti@polytechnique.edu
Yannis Laplace, yannis.laplace@polytechnique.edu

Nonlinear TeraHertz surface plasmon resonators

Context: In the past years, numerous efforts have been devoted to the scientific and technological development of the Terahertz (THz) frequency range [1]. Towards that goal, the realization of analogues of nonlinear optics in the THz frequency range is of critical importance. At optical frequencies, nonlinear optical processes play a pivotal role in advancing technology and form the basis of phenomena such as frequency conversion and information processing. Successfully mastering these phenomena at THz frequencies will be instrumental for the development of the technology in this range.

PhD research program: In this context, we have recently developed THz cavities that operate using a plasmonic mechanism based on the surface plasmons of a doped semiconductor [2]. We have demonstrated the remarkable property of these resonators of being able to confine TeraHertz photons in record volumes of the order of 10^{-7} times smaller than the diffraction limit. This plasmonic mechanism also allows the functionalization and tunability of the cavities thanks to external parameters such as the electric and magnetic fields or the temperature. The aim of this PhD project will be to develop THz plasmonic cavities and to study their nonlinear behaviour when subjected to intense THz pulses. A main goal of the project will be to realize analogues of nonlinear optics in the THz frequency range, such as harmonic generation, parametric conversion, optical bistability, etc. Overall, this would allow to help bridging the so-called "THz gap". The project will cover aspects such as the design, the fabrication and the measurement of plasmonic resonators. The experimental studies will be a complemented with numerical simulations, both in the linear and nonlinear regime of light matter interaction.

[1] A. Leitenstorfer et al., The 2023 terahertz science and technology roadmap, J. Phys. D: Appl. Phys. 56 223001 (2023)
[2] I. Aupiais, R. Grasset, T. Guo, D. Daineka, J. Briatico, S. Houver, L. Perfetti, J.-P. Hugonin, J.-J. Greffet and Y.Laplace , Ultrasmall and tunable TeraHertz surface plasmon cavities at the ultimate plasmonic limit, Nat. Commun 14, 7645 (2023)

Environment :
The hosting group Nouveaux Etats Electroniques group (NEE) is expert in non-equilibrium dynamics of quantum materials, both at optical and THz frequencies. The PhD student will operate a KiloHertz amplified ultrafast laser providing femtosecond pulses of 5 mJ. The lab is equipped with a THz pump-probe spectroscopy setup and an optical cryostat suitable to carry on the studies. Finally, the supervisors Luca Perfetti and Yannis Laplace have large experience in THz spectroscopy, non-equilibrium phenomena in correlated condensed matter as well as superconducting and semiconducting plasmonics.

Profile :
We are looking for a motivated candidate with a strong knowledge in condensed matter physics. Basic knowledge in ultrafast optics, optical and/or THz spectroscopies will be a plus.
Applicants should send a detailed CV, a 1-page cover letter as well as the names and contact details of two references to: luca.perfetti@polytechnique.edu and yannis.laplace@polytechnique.edu