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
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Terahertz Cavity Electrodynamics of Superconducting Collective Modes

Context: Light control of a material's properties is an emerging field with potentially far-reaching applications. Within this field enhancing or modifying superconductivity (SC) holds a special place ever since the discovery of a superconducting-like state in several materials well above their equilibrium SC temperature [1]. The dynamics of superconductors driven out-of-equilibrium is governed by their collective mode spectrum, and in particular the SC amplitude mode which is an analog of the Higgs mode in high-energy physics [2]. These SC collective modes not only give fingerprints of the nature of the ground state, but also a path to dynamically drive or even control SC order.
Light control of SC may be achieved through two main routes. The first involves driving the collective modes with light pulses tuned to their energy, typically in the THz frequency range, which may dynamically modify SC properties such as the pairing potential and explore new regions of the free energy landscape inaccessible via static means. The second route involves dressing the SC collective modes with vacuum fluctuations through strong light-matter coupling in THz cavities [3,4] aiming to harness hybrid light-matter states to engineer novel equilibrium phases of matter without external driving.
PhD research program: In this thesis project, we propose to address these two routes with $NbSe_2$, an exotic SC hosting simultaneously SC and a charge-density-wave (CDW) state. With pump-probe THz time domain spectroscopy, the candidate will investigate the dynamics and interaction of the Higgs and CDW modes when driven far away from equilibrium and the possibility to induce long-lived metastable SC states in this system. The thesis project will further aim at dressing its collective modes via integration of this SC inside THz cavities in order to create hybrid light-SC matter states and to explore their impact on SC properties.

[1] Fausti et al. Science 331, 6014 (2011): 189 91.
[2] Pekker and Varma, Annual Review of Condensed Matter Physics 6, (2015): 269 97.
[3] Garcia-Vidal et al. Science 373, 6551 (2021).
[4] Raines et al. Physical Review Research 2, n(2020): 013143.

Environment :
The hosting group Nouveaux Etats Electroniques (NEE) is expert in equilibrium and non-equilibrium dynamics of superconductors. The student will operate a KiloHertz amplified laser system providing femtosecond pulses of 5 mJ. The THz spectrometer and optical cryostat are installed and regularly operating. The supervisors Yannis Laplace and Romain Grasset have large experience both on THz cavity design and fabrication and THz spectroscopy of superconductors.
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: yannis.laplace@polytechnique.edu and romain.grasset@polytechnique.edu