ESPCI PARIS

Master internship

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Physics and Materials Laboratory
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Local THz photons for coherent light-matter interaction

Condensed matter systems are the center of many game-changing technologies: superconductivity for example has allowed quantum-limited amplifiers for more sensitive detection schemes, and ferromagnetic material holds the promise for energy-efficient computation with the development of spintronics. The detection of these collective states requires energies in the meV range which corresponds to THz frequencies. Unfortunately, at such high frequencies, dielectric and metallic losses will attenuate the information conveyed by an electromagnetic signal.

In the infrared spectrum, scanning near-field microscopy has demonstrated that it was possible to exploit the confinement of the electric field to enhance the response of materials below the diffraction limit. At THz frequencies, recent development in the time domain spectroscopy techniques [1] suggests the possibility of addressing single lumped resonators [2]. Combining the near-field capabilities of optical tools and the recent advances in circuit-quantum electrodynamics, we propose to probe coherent excitations in condensed matter systems.

To reach mesoscopic lengths and increase the coupling with the collective excitations, a THz signal will be conveyed to a lumped resonator coupled capacitively or inductively to the system of interest, depending on the nature of the collective mode. In parallel, the non-linearity induced by a thin superconducting film can be harnessed to realize four-wave parametric frequency conversion [3]. Developing this technology is key to creating an integrated THz detection platform. Finally, to convey the signal from the converter to the resonator, an all-silicon topological metamaterial will be designed. These metamaterials have already been used to strongly attenuate the losses due to radiation [4]. Altogether, these tools will give access to collective excitations in samples of small size that are currently not accessible. One can think of magnon in graphene [5] for example.

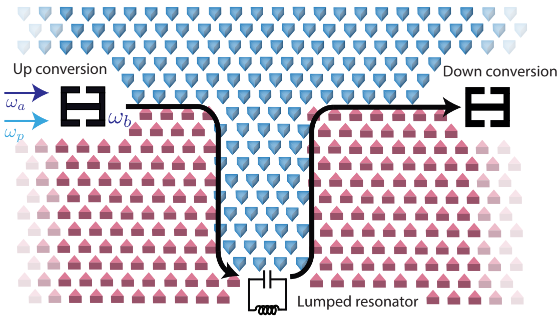

Figure 1: Schematic of a THz local sensing platform. On-chip frequency conversion allows for a short distance over which the THz signal will propagate. A lumped resonator coupled to the system under study is probed using a coherent excitation.

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