Laboratoire Pierre Aigrain - Ecole Normale Supérieure

INTERNSHIP PROPOSAL

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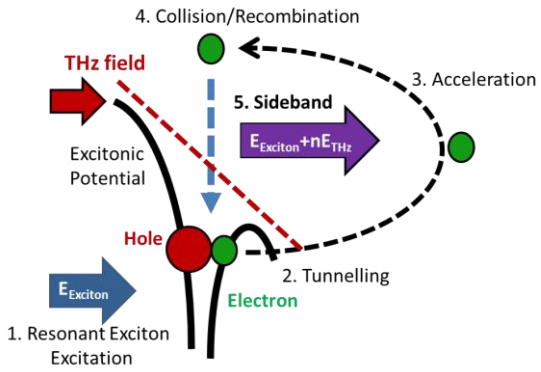
Quasi-particle collisions in 2D semiconductors

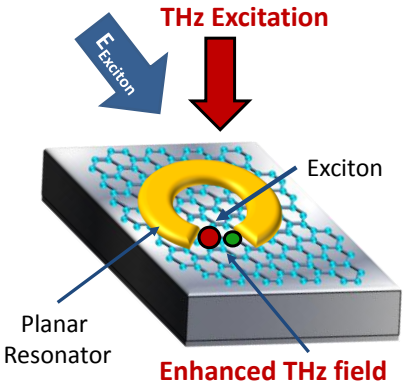
Context: Terahertz (THz) nonlinear optics is an emerging and active research field that takes advantage of recent breakthroughs in THz technologies. A growing number of studies using THz excitations to induce giant nonlinearities are being investigated, allowing insights into fundamental science as well as potential applications. This includes, for example, exotic transport regimes in semiconductors, spin excitations in magnetic materials as well as new sources and functionalities in previously inaccessible or underdeveloped spectral regions.

Internship Subject: Recently high order sideband generation (HSG) has been demonstrated in condensed matter systems, akin to high harmonic generation (HHG) observed in gas mediums which forms the basis of attosecond research. Here the internship will investigate practical generation of HSG through compact semiconductor THz pump lasers (quantum cascade lasers) and highlight two different regimes of HSG; the classical regime through physical electron-hole collisions in large binding energy excitons (e.g. excitons in monolayer WSe2 – see left figure) and the quantum regime through the overlap of the electron and hole wavefunctions in monolayer materials such as graphene. This studies will be combined with meta-material resonators to enhance the nonlinear interactions (see right figure). This will permit insights into the dynamics of these new 'collisions' and go beyond the use of entire facilities or high power femtosecond laser technology for their applications in wavelength shifting and spectroscopy applications.

Subject areas: Condensed matter physics; Experimental photonics; THz and MIR spectral regions; Investigations of 2D semiconductor materials and devices



Schematic of High Sideband Generation. A resonant excitation of the exciton is driven by a THz excitation. The electron is separated from the hole by the THz field followed by a collision with a hole that releases a high energy sideband.



Meta-material. Planar resonator integrated on top of the 2D transition metal dichalcogenides or graphene to enhance the nonlinear interaction around the exciton