Master thesis proposal

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Director: Pierre Lefebvre

Title: Superradiance of optical phonons in hexagonal boron nitride

Keywords: phonons, spontaneous emission, boron nitride

Scientific description: The objective of the project is to observe the luminescence of 2D optical phonons, and to study their superradiance during the 2D-3D crossover of the light-matter interaction. Phonons are the quanta of vibrations in a crystalline lattice. When a solid-state system is subjected to an external excitation, its relaxation to thermodynamic equilibrium generates non-equilibrium phonons, which propagate and encounter scattering events at the origin of heat diffusion. The phonon relaxation dynamics is thus mostly non-radiative, and **phonons are usually considered only as a dissipative reservoir**.

We intend to demonstrate that **phonons can also generate light**. Following our recent paper bringing the evidence for a radiative efficiency of order 10% for optical phonons in monolayer boron nitride [Cas22], we aim at detecting and controlling the luminescence of non-equilibrium phonons in hexagonal boron nitride. Our strategy relies on experiments in this 2D material by means of our scanning confocal cryo-microscope operating from the UV-C to the mid-IR spectral ranges [Cas16,Cal19,Val20,Rou21]. A key aspect of the project will be to study the build-up of superradiant phonons as a function of the number of atomic layers. **Superradiance appears as a key resource for the observation of the luminescence of non-equilibrium phonons** with the perspective of reaching radiative efficiency of order unity [Cas22b].

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Techniques/methods in use: Optics / Microscopy / InfraRed
Applicant skills: background in condensed matter physics, quantum physics, and optics.
Industrial partnership: No
Internship supervisor: Guillaume CASSABOIS, guillaume.cassabois@umontpellier.fr
Internship location: Team « Solid-State Quantum Technologies », Laboratoire Charles Coulomb, Montpellier.
Possibility for a Doctoral thesis: **Yes (secured funding)**