INTERNSHIP PROPOSAL

(One page maximum)

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Thesis possibility after internship: **YES**
Funding: **requested** If YES, which type of funding: **Doctoral school + European project**

Generating light with phonons in 2D materials

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 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.

The objective of this PhD project is 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 intend to detect and control 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 PhD 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].

[Cas22] G. Cassabois, G. Fugallo, C. Elias, P. Valvin, A. Rousseau, B. Gil, A. Summerfield, C. J. Mellor, T. S. Cheng, L. Eaves, C. T. Foxon, P. H. Beton, M. Lazzeri, A. Segura, and S. Novikov, Phys. Rev. X 12, 011057 (2022).
[Cas16] G. Cassabois, P. Valvin, and B. Gil, Nat. Phot. 10, 262 (2016).
[Cal19] J. Caldwell, I. Aharonovich, G. Cassabois, J. Edgar, B. Gil, and D . Basov, Nat. Rev. Mat. 4, 552 (2019).
[Val20] P. Valvin, T. Pelini, G. Cassabois, A. Zobelli, J. Li, J. H. Edgar, and B. Gil, AIP Adv. 10, 075025 (2020).
[Rou21] A. Rousseau, L. Ren, A. Durand, P. Valvin, B. Gil, K. Watanabe, T. Taniguchi, B. Urbaszek, X. Marie, C. Robert, and G. Cassabois, Nano Lett. 21, 10133 (2021).
[Cas22b] G. Cassabois, G. Fugallo, and B. Gil, Phys. Rev. Res. 4, L032040 (2022).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: **YES** Soft Matter and Biological Physics: NO
Quantum Physics: **YES** Theoretical Physics: NO