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Project title: Tunable excitonic response in patterned hexagonal boron nitride	
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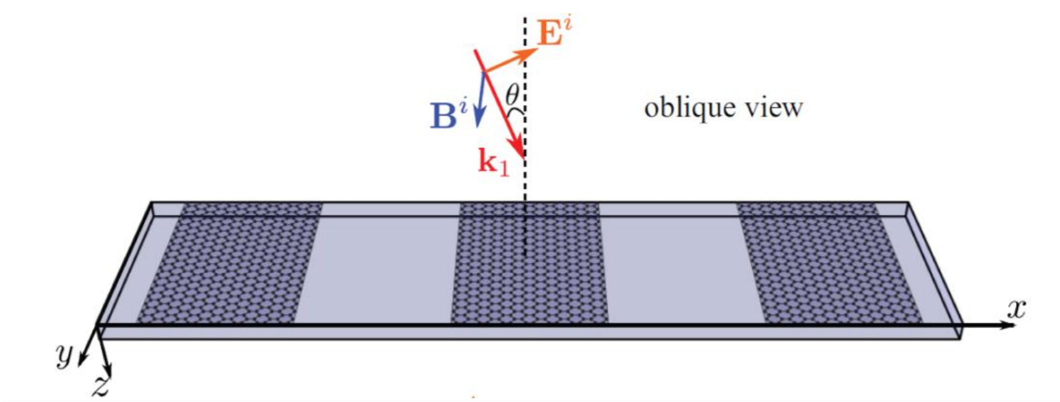
PROJECT DESCRIPTION:

The advent of two-dimensional (2D) materials, with the emergence of graphene in 2004 [1], has revolutionised modern optics. In the years that followed, an entire zoo of atomically thin materials with exciting mechanical, electrical and optical properties was proposed and isolated in the lab. In terms of optics, the most interesting characteristic of such 2D layers is that they can host a variety of polaritons: collective oscillations of some fundamental unit (e.g. electrons or phonons), triggered by external light [2]. Among them, hexagonal boron nitride (hBN) remained for some time the "poor relative": the inactive material that would encapsulate and protect the more "interesting" layers. Nevertheless, hBN can also have a polaritonic response, both in the form of phonon polaritons in the infrared [3], but also with the far-less explored exciton polaritons in the ultraviolet [4].



The aim of this project is to draw inspiration from the extended literature on graphene and investigate similar patterning techniques for hBN. These can include nanoribbons [5], wedges [6], dot and antidot arrays [7], or thin coating layers to encapsulate other nanoparticles [8]. The project will be theoretical, with a starting point in analytical derivations and with possibility of extending the investigations using numerical methods. After developing a basic understanding of the emergence of excitons in hBN, the student will focus on one or two of the possible geometries, reproduce the corresponding analytic solutions from literature, produce the required code in their favourite language, and use as input the hBN permittivity of Ref. [4] to calculate and interpret the optical properties of the selected system, and how they can be tuned with geometry.

[1] K. S. Novoselov et al. – Science **306**, 666 (2004).
[2] D. N. Basov et al. – Science **354**, aag1992 (2016).
[3] J. D. Caldwell et al. – Nat. Com. **5**, 5221 (2014).
[4] F. Ferreira et al. – J. Opt. Soc. Am. B **36**, 674 (2019).
[5] P. A. D. Gonçalves et al. – Phys. Rev. B **94**, 195421 (2016).
[6] T. P. Rasmussen et al. – ACS Photonics **8**, 1840 (2021).
[7] X. Zhu et al. – Nano Lett. **14**, 2907 (2014).
[8] T. Christensen et al. – Phys. Rev. B **91**, 125414 (2015).