Engineering of excitonic complexes in van der Waals heterostructures

Fabien Vialla[a*], M. Massicotte[b], P. Schmidt[b], and F.H.L. Koppens[b]

a. iLM – Institut Lumière Matière, UMR5306 CNRS, Université Claude Bernard Lyon 1, Bâtiment Kastler 10 rue Ada Byron, 69622 Villeurbanne CEDEX, France
b. ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, Castelldefels, Barcelona 08860, Spain

* *fabien.vialla@univ-lyon1.fr*

Opto-electronic properties of transition metal dichalcogenides (TMDs) are largely governed by coulomb-mediated many body interactions stemming from quantum confinement and reduced screening. This results in the emergence, upon light excitation, of tightly bound electron-hole complexes stable even at room temperature. Furthermore, integration of TMDs in van der Waals heterostructures allows to engineer those quasiparticles. The recent maturity reached by the nanofabrication of these heterostructures now offers a unique platform to study original physics in low-dimensional systems.

In this talk, I will give an overview of our recent studies based on spectrally- and temporally-resolved measurements of the photoluminescence and photocurrent originating from TMDs integrated in several devices with different designs. The fine tuning of the electrostatics achieved using local gates leads to the characterization and manipulation of the excitonic complexes generated in mono- [1], multi- [2] and heterolayers [3] of TMDs. By contacting the TMDs with graphene layers, we can probe the complexes dissociation dynamics and follow the subsequent intra- [1] or interlayer [2,4] transport of the free charges. Overall we extract important insights on the photophysics of these low-dimensional systems and identify guidelines for future fundamental and technological opto-electronic applications based on TMD.

[1] M. Massicotte, F. Vialla *et al.*, Dissociation of 2D excitons in monolayer WSe2, Nature Communications 9, 1633 (2018)
[2] M. Massicotte, P. Schmidt, F. Vialla *et al.*, Picosecond photoresponse in van der Waals heterostructures, Nature Nanotechnology 11, 42-46 (2016)
[3] F. Vialla *et al.*, submitted
[4] M. Massicotte, P. Schmidt, F. Vialla *et al.*, Photo-thermionic effect in vertical graphene heterostructure, Nature Communications 7, 12174 (2016)