Master 2 Physics–Condensed Matter and Nanophysics

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Single photon sources in atomically thin semiconductors

Layered materials (i.e., graphene and related materials) provide a genuine toolkit for novel opto-electronic devices [1]. In particular, transition metal dichalcogenides (TMD, such as MoS_2, $MoSe_2$, $MoTe_2$, WS2, WSe2) are endowed with peculiar optical, spin and valley properties, especially when they are thinned down to the two-dimensional limit (i.e., monolayer thickness) [2]. It has recently been shown that such atomically thin semiconductors could host isolated quantum emitters (attributed to defect sites) that can be electrically or optically driven to produce bright single photon sources [3]. However, although the emission from these defects has been well characterized, the nature of the defects that give rise to non-classical emission as well as the possibility to tailor these defects remain largely unexplored.

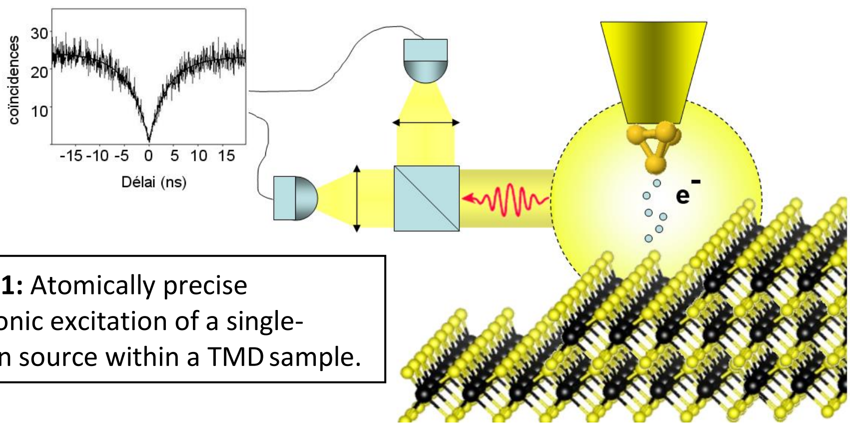

Figure1: Atomically precise electronic excitation of a single-photon source within a TMD sample.

This project aims at probing and controlling the electronic and optical properties of atomically thin TMD with an atomic-scale precision. Monolayer TMD samples will be fabricated in the in the StNano clean room and thoroughly characterized optically to identify single quantum emitters using time correlated single photon counting at variable temperature. The same samples will then be studied with a low temperature (4k) scanning tunneling microscope (STM) operating under ultra-high vacuum. We will characterize the sample surfaces at the smallest possible scale and determine their electronic structure. Our setup also makes it possible to probe the electroluminescence of these materials (cf. Fig. 1) [4]. **Our long term objective is to demonstrate electrically driven single photon sources in view of innovative optoelectronic applications. This internship will launch collaboration between two IPCMS teams working on STM and 2D materials.**

Useful references:

[1] K. S. Novoselov *et al.*, *2D materials and van der Waals heterostructures*
Science **353**, 6298 (2016) (lien)(arxiv:1307.6718)
[2] K.F. Mak & J. Shan*, Photonics and optoelectronics of 2D semiconductor transition metal dichalcogenides*
Nature Photonics. **10**, 216 (2016) (link)
[3] V. Perebeinos, *Metal dichalcogenides: Two dimensions and one photon*
Nature Nanotechnology **10**,485 (2015) (link) (news and views article: see the cited articles as well!)
[4] G. Reecht *et al.* "*Electroluminescence of a Polythiophene Molecular Wire Suspended between a Metallic Surface and the Tip of a Scanning Tunneling Microscope.* Phys. Rev. Lett. **112**, 047403(2014) (link)