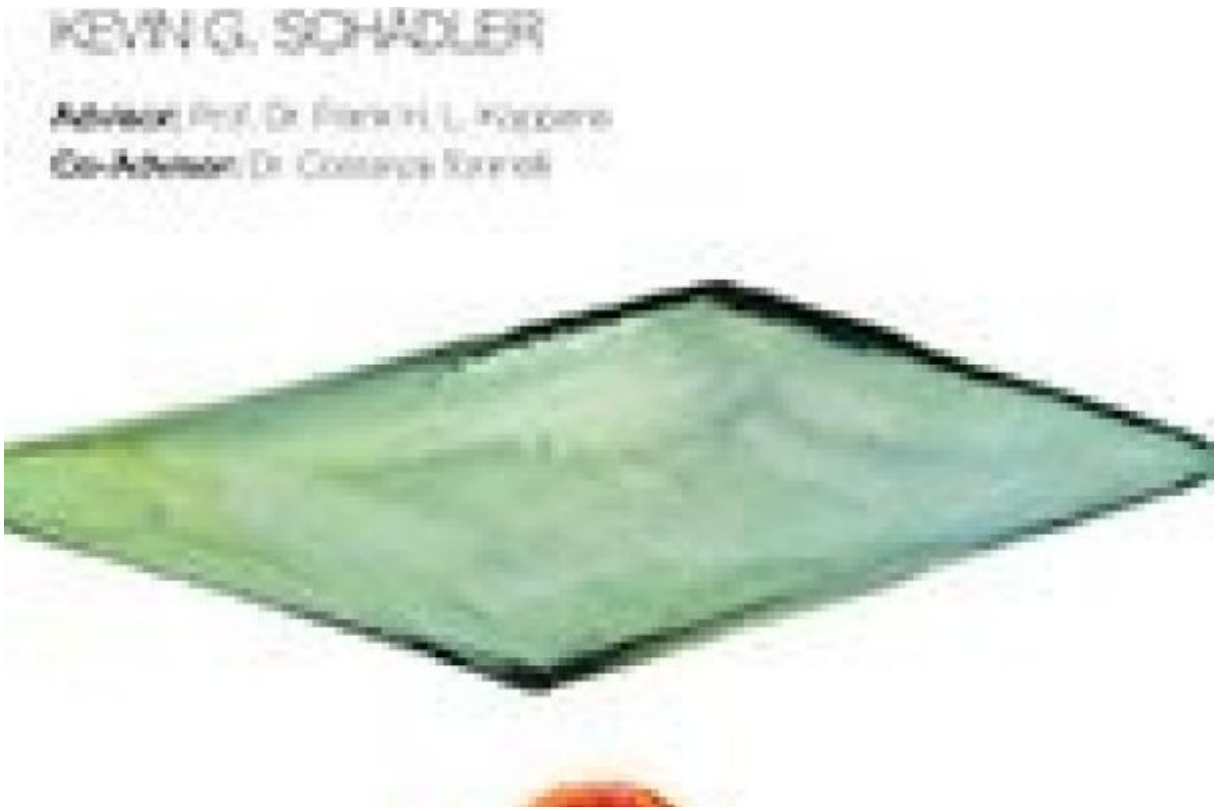

PhD Thesis Defense KEVIN SCHAEDLER 'Single Quantum Emitter Manipulation with 2D Materials'

KEVIN SCHADLER

May 22, 2018

Tuesday, May 22, 10:00. ICFO Auditorium

KEVIN SCHADLER

Quantum Nano-Optoelectronics

ICFO-The Institute of Photonic Sciences

Photonics aims to manipulate light by controlling its interactions with matter to enable novel optical technologies for communication, information processing and sensing. Current efforts strive to enter the regime of quantum nanophotonics, where light interacts with nanoscale photonic elements at the single photon level. The realisation of such systems is challenging due to weak light-matter interaction at the nanoscale, which motivates the quest for new strategies and nanomaterials with enhanced interaction.

In this context, nanoscale solid state quantum light emitters which mimic the efficient interactions of trapped atoms with light are a key element for implementing quantum optical devices on chip.
The coupling of these quantum emitters to their nanoscale environment has two important consequences: i) controlling the environment enables control of the emitter, while conversely ii) the emitter acts as a nanoprobe of its environment. Therefore, hybrid systems which integrate such emitters with a controllable nano-environment enable manipulation of nanoscale quantum light. Two-dimensional (2D) materials are a particularly promising platform for this purpose due to their unique blend of optoelectronic and mechanical properties which enable efficient, tuneable light-matter interactions and sensitive nanomechanical resonators with ultra-low mass and high mechanical resonance frequency.

In this thesis, I will introduce two different hybrid systems which integrate nanoscale quantum emitters with two-dimensional (2D) materials such as atomically thin graphene and MoS2. I will first present a hybrid nano-optomechanical system which harnesses efficient near-field interactions to couple the nano-motion of a 2D mechanical graphene resonator to the emission strength of a quantum emitter (nitrogen vacancy centre, NVC) at a separation below 40 nm. In this system, electromechanical control of graphene?s nano-motion enables high-frequency (100 MHz) emission modulation, while conversely, the NVC acts as a transducer which enables optical readout of nano-motion in the photon counting regime.

In the second part of the thesis, I demonstrate that single molecules embedded in organic nanocrystals in a polymer display bright single photon emission with ultra-narrow linewidth close to the lifetime-limited value (~ 40 MHz). I show that these emitters can be integrated with 2D materials at sub-wavelength separation in a hybrid optoelectronic device without emission perturbation. Using the 2D materials as transparent electrodes, the device?s nanoscale dimensions enable ultra-broadband tuning (tuning range > 400 GHz) and fast modulation (frequency ~ 100 MHz) of the emission energy, which renders it an integrated, ultra-compact tuneable single photon source.

These results demonstrate the potential of 2D materials for controlling quantum emitters and the use of an atomically small object to probe optoelectronic and mechanical properties of atomically thin materials.

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