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Control of quantum light emission from 2D materials

Photonics based on two-dimensional (2D) materials has made incredible progress in the last years and currently sets the state of the art for a number of applications in optoelectronics and optics. Recently, 2D materials have also begun to impact the field of semiconductor quantum optics through the demonstration of stable quantum emitters in semiconductor transition metal dichalcogenides (TMDs) and hexagonal boron nitride (hBN). Despite the great promise of this system, a few challenges still need to be tackled before promoting this system for real quantum applications.

In this work, we focus on the quantum emission from atom-like defects in 2D hBN with particular attention to the broad inhomogeneous spectral distribution. Our experiments were able to link this multicolor emission to variations of the electromagnetic environment with the development of a method to actively tune the emission energy by externally modifying strain. This fabrication process produces a tunable ultra-bright room-temperature single photon source with the advantages of 2D materials, including transferability, stretchability, heterogeneous device assembly and straightforward integration with photonic circuits.

In the second part of the talk, we present our current research aimed at the investigation of the vibronic states in hBN molecules for enhanced quantum efficiency of the single-photon emission. Our photoluminescence excitation experiments show that light absorption is more efficient when mediated by in-plane optical phonons. Enhanced absorption results in higher quantum efficiency when emitters are excited by non-resonant pumping with detuning in the range 150-200 meV. By interfacing our experimental results with theoretical calculations of the phononic modes of hBN and simulations based on DFT methods, we are making progress towards the understanding of the nature of active structural defects in hBN.