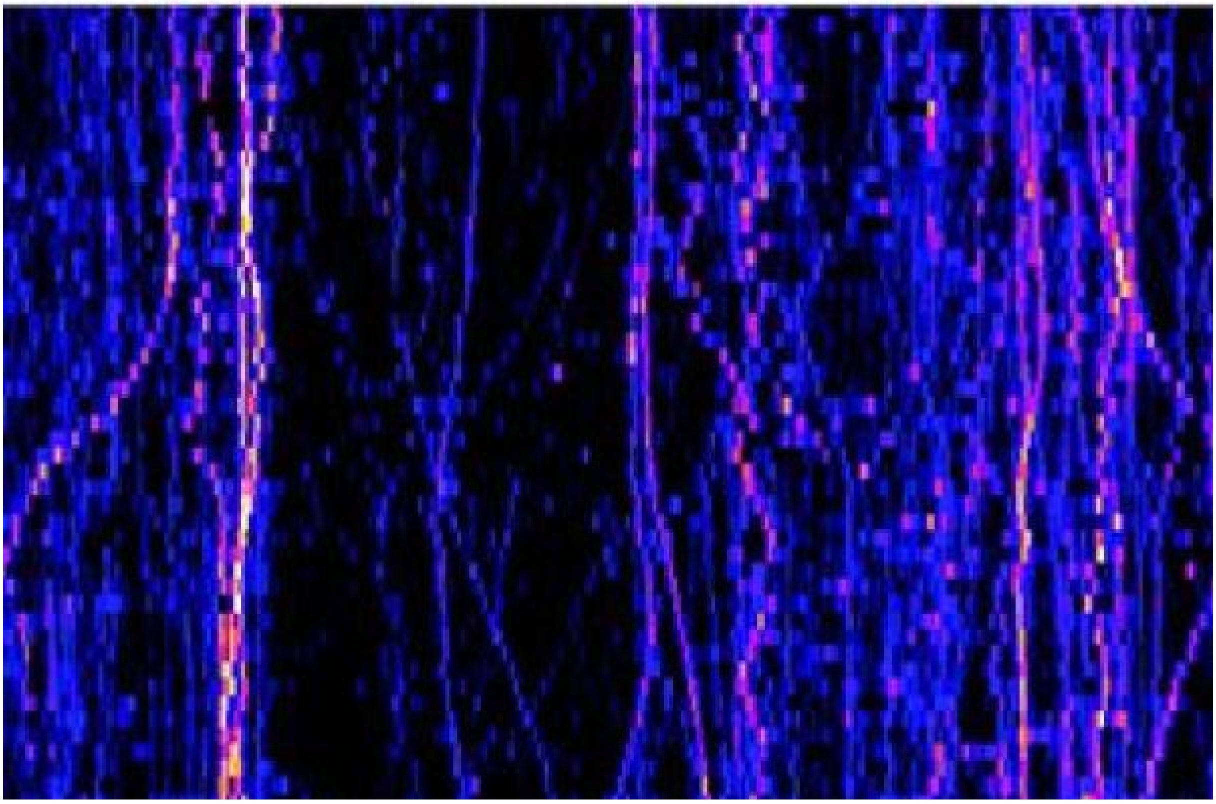

PhD THESIS DEFENSE: Integration and Electrical Manipulation of Single-Photon Sources in 2-Dimensional Devices

CARLOTTA CIANCICO

December 09, 2021

10:00

ICFO Auditorium and Teams

Quantum nanophotonics aims at studying the interaction between matter and single photons at the nanoscale. Nanoscopic solid state light sources can be placed in near proximity to other photonic elements to engineer their environment and modify their behaviour by near-field effects. The use of quantum emitters guarantees on-demand single photons following a non-classical statistics, therefore allowing new types of phenomena at the nanoscale. The nanometer-sized single photon sources used in this thesis are stable, bright, narrow linewidth organic molecules. They are also scalable and reproducible, making them ideal for integration into a device as well as for tuning and sensing.

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In this thesis, we developed an original approach to explore near-field effects by combining ultranarrow linewidth quantum emitters with 2-dimensional materials. We present the experimental setup based on confocal microscopy at cryogenic temperatures allowing us to excite and collect emission from individual elements of the hybrid device.

We first introduce a geometry of a device consisting of a capacitor where the 2-dimensional material is used as a transparent, non-invasive top electrode, deposited above a layer of polymer doped with quantum emitters. This configuration enables tuning of the single-photon emission by Stark shift over a range of 10^4 times the molecule's intrinsic linewidth. Dynamical modulation of the emission at high frequency (similar to the molecule's linewidth of approximately 100 MHz) is performed revealing interesting properties of the 2-dimensional electrode.

Another geometry explored in this thesis is achieved by depositing doped nanocrystals on top a graphene field-effect transistor. We study the electrostatic behaviour of the device at different locations, observing anomalies in the Stark shift of the molecules' emission at the edge of the graphene device compared to the centre. We predict the saturation of atomic-scale defect states at the edge of graphene, as supported by our electrostatic model. A technique based on electron beam lithography of polymers for deterministic positioning 3D structures aligned on quantum emitters' location is also presented.

Thursday, December 9, 2021, 10:30. ICFO Auditorium and Online (Teams)

Thesis Director: Prof Dr. Frank Koppens

Thesis Co-Director: Dr Antoine Reserbat-Plantey

Hosted by: Prof Dr. Frank Koppens (Thesis Director) and Dr Antoine Reserbat-Plantey (Thesis Co-Director)

Carlotta Ciancico's Thesi Cover