MASTER IN PHOTONICS – "PHOTONICS BCN"
ERASMUS+ "EUROPHOTONICS-POESII"

MASTER THESIS PROPOSAL

Dates: spring-summer 2019, starting date can be discussed

Laboratory: **Molecular NanoPhotonics – Niek van Hulst group**
Institution: **ICFO**
City, Country : **Castelldefels - Barcelona**

Title of the master thesis:

"A bright and pure photon source:
Strong coupling of a single molecule to a plasmonic nano-antenna cavity"

Name of the master thesis supervisor:
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Keywords :

- Ultrafast: single photon stream > GHz
- Coupling above 1 THz
- Spatial confinement < 10 nm

Summary of the subject (maximum 1 page) :

Light is the most powerful carrier of information for our communication. More and more, single photons are explored for quantum communication. Yet most photon sources have their limits in yield and quality of the photon emitted.
The main goal of this project is to craft a bright and pure singe photon source. We exploit concepts of cavity QED to boost the light field and enhance light-matter interaction with photon emitters, such as molecules and point defects. The novelty and strength of this project is the application of nanophotonic antennas as nanocavities with deeply localised mode volumes and very high radiation efficiency. The challenge is to put the photon emitter exactly right inside the nanoscale mode volume. In the project we will use both nanofabrication at ICFO clean room and nano-manipulation on the group's scanning antenna microscopes.
Getting the positioning right, single photon output should be hugely accelerated, providing fast and pure non-classical single photon emission with brightness of 10^9–10^{12} photons/sec: a bright on-demand and ultrafast single photon nanosources for quantum technologies.

More importantly, a single molecular photon sources filling a nanometre field confinement is the ideal condition for strong coupling up to several THz. We will aim to achieve this strong coupling condition at which the molecular states and the optical field enter into a superposition state, allowing to tune both the molecular and cavity response. The bright photon emission and strong coupling give rise to a plethora of fascinating effects of both scientific and technological interest.

Additional information :

Required skills:
Exact Sciences; Physics; Engineering; Nanotechnology; or Physical Chemistry.
Interest in experimental research, nanotechnology, quantum phenomena.
Assertiveness and group spirit.

Training outcome:
- Skills: nanofabrication, nanocontrol, single photon detection, single molecule detection, super-resolution, ultrafast detection, pulse lasers, focussed ion-beam milling, e.m.-field simulations;
- Insight: mode density, quantum-optics, plasmonic modes, optical antennas fields, photon statistics;
- Getting prepared for a PhD project and position;
- Report of master project culminating in a publication.

Related recent literature of the group:
NanoLett. 18 (4), pp 2538–2544 (2018); *Nature Photonics* **12**, 46-49 (2018); *Nature Communications* 7:10411 (2016); *J.Phys.Chem.Lett.* 7, 1604-1609 (2016); *Nature Communications*. 5: 4236 (2014); *NanoLetters* 14, 4715-4723 (2014).