Study of quantum electrodynamics effects in cavity with carbon nanotubes [1]

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[1] prof.Christophe Voisin, dr.Yannick Chassagneux

How does a quantum network work?

Quantum information - the flying qubit

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- information processing in network's nodes $\rightarrow$ stationary qubits

Quantum information - the flying qubit

How does a quantum network work?

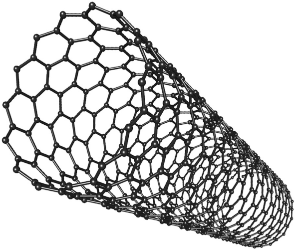
- information processing in network's nodes $\rightarrow$ stationary qubits
- decoherence-free information exchange between nodes $\rightarrow$ flying qubits

Photons polarization can encode informations!

Why CNTs?

Key requirements for quantum telecommunication:

- NIR emission
- high emission efficiency



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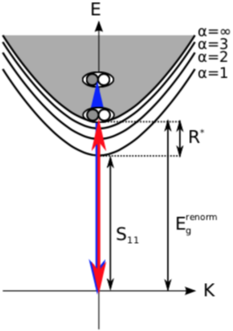
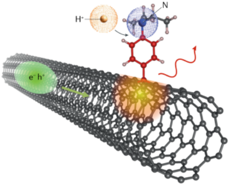


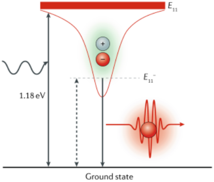
The Nano-optique group work

How to boost and control the emitting features of CNTs?



Two parallel paths:

- modification of crystalline structures, environment and chemical features of materials

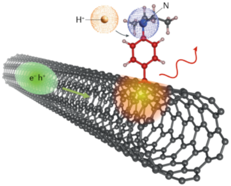


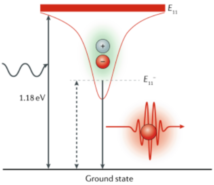
The Nano-optique group work

How to boost and control the emitting features of CNTs?

Two parallel paths:

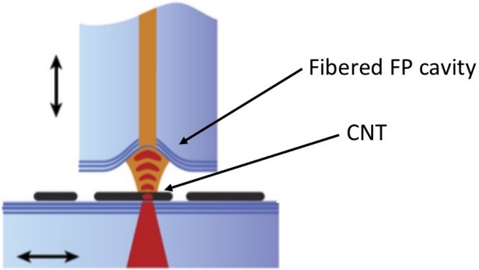
- modification of crystalline structures, environment and chemical features of materials
- photonic tools to reshape the emission properties of emitting material





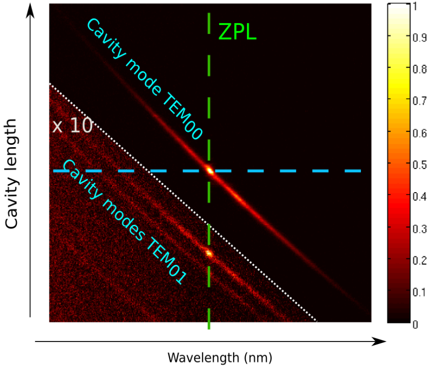
Carbon nanotubes in cavity

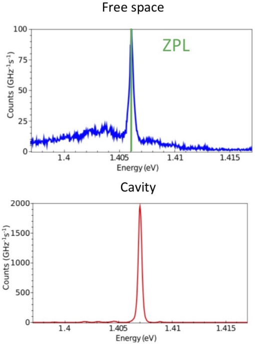
- Fibered Fabry-Perot cavity
- RT excitonic states exploitation for tuned optical transitions



Collaboration with Jacob Reichel, LKB

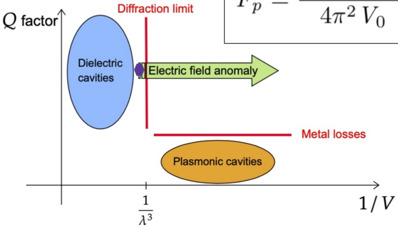
- Fibered Fabry-Perot cavity.
  Spectral and spatial coupling of CNTs

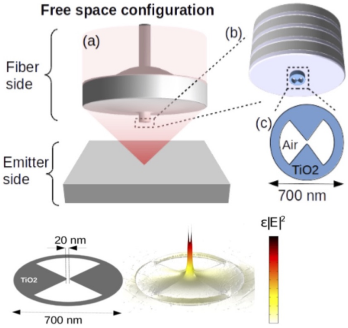




The deep-subwavelngth regime

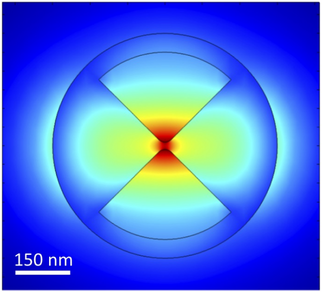
$$F_p = \frac{3Q(\lambda/n)^3}{4\pi^2 V_0}$$





Sub-diffraction image of the intensity map

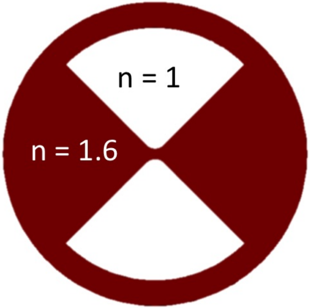
"Diverging" optical field



EM field finite element simulation

Sample preparation

Dielectric nano-antenna



Sample preparation

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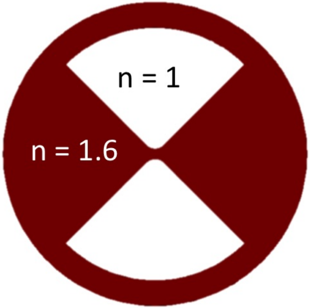
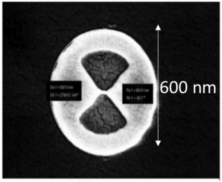


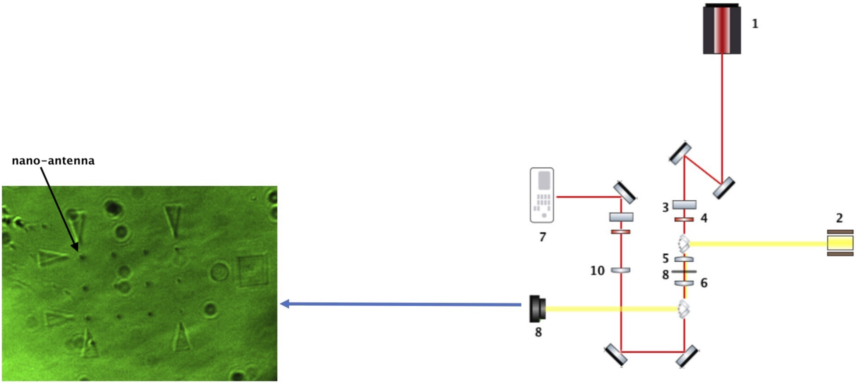
Sample fabrication



nano-bridge

nano-gap

Sample characterization



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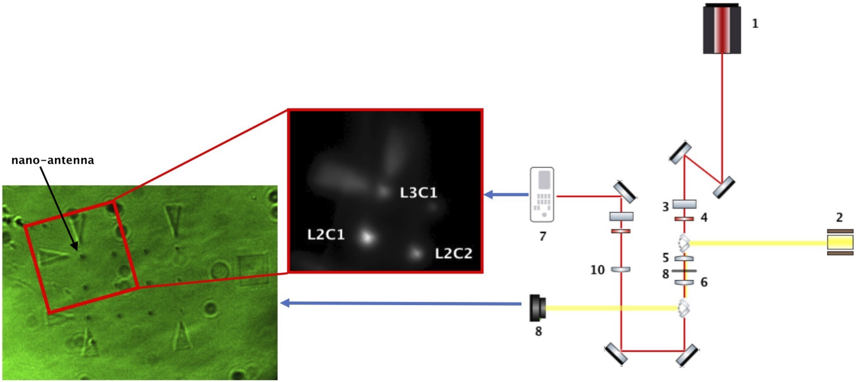
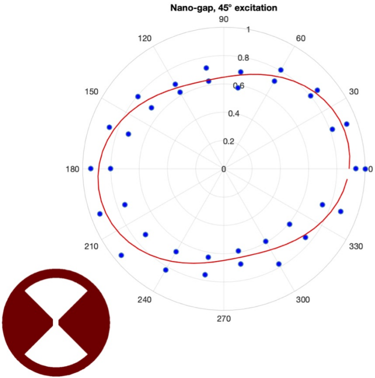
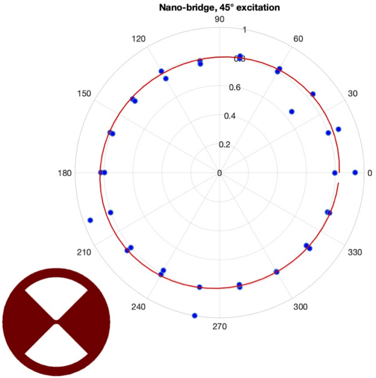


Polarization measurements





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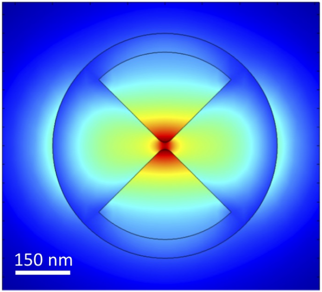
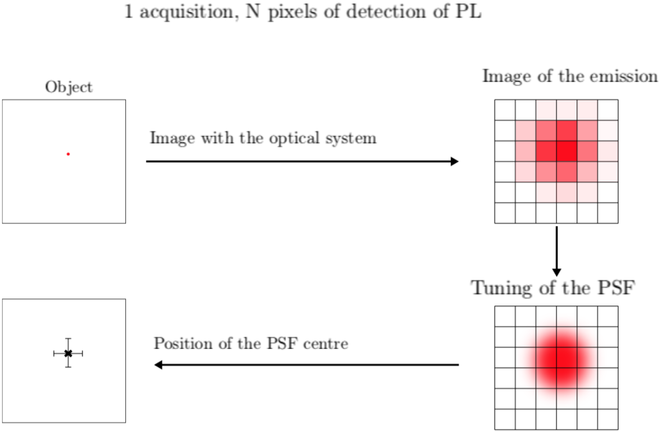


EM field finite element simulation

Super-resolution technique



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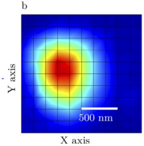

C. Raynaud, T. Claude, A. Borel, M. Amara, A. Graf, et al.. Superlocalization of Excitons in Carbon Nanotubes at Cryogenic Temperature. Nano Letters, American Chemical Society, 2019, 19 (10), pp.7210-7216.

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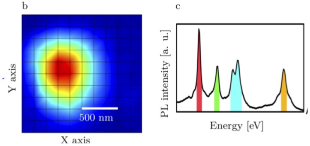

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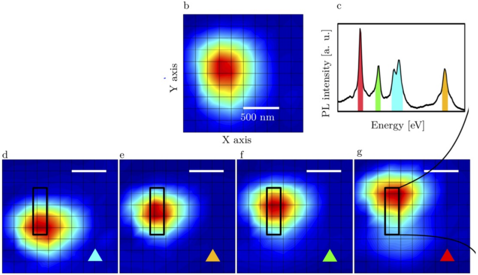

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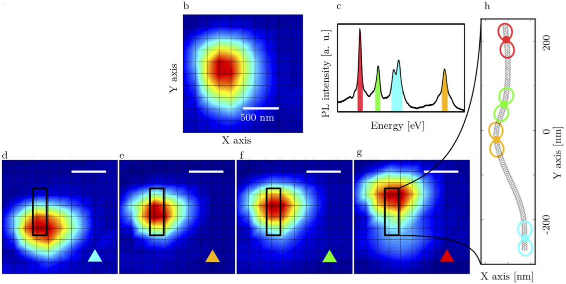

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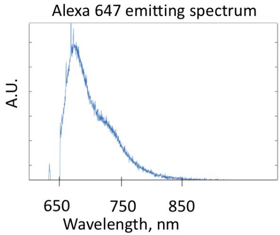
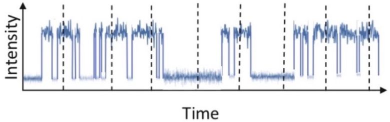
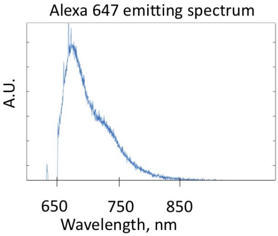
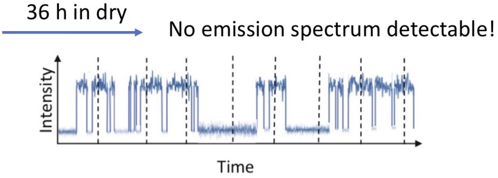
Organic dye for super-resolution



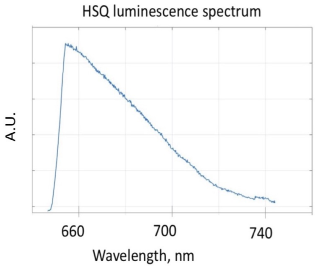






- New route: Alexa + polystyrene matrix

HSQ for super-resolution



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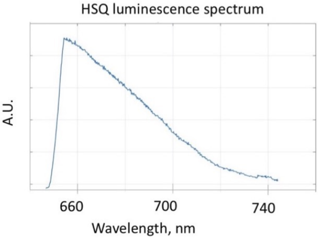


Statistical blinking

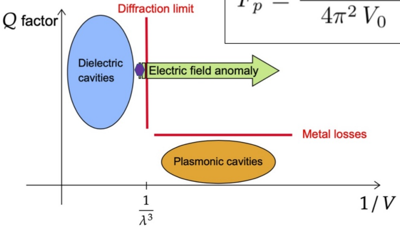
	standard deviation	Shot-noise	std/noise
laser	120 ± 10	115 ± 10	~ 1
L3C1 antenna	135 ± 10	130 ± 10	~ 1

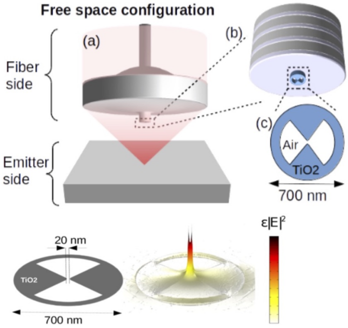
My internship so far

- Coupling of CNTs in cavity (in collaboration with PhD student Antoine Borel)
- Nano-antenna design and production
- Setup design and building
- Preliminary steps towards super-resolution measurements

Towards a new physics

$$F_p = \frac{3Q(\lambda/n)^3}{4\pi^2 V_0}$$





Acknowledgments

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PhD Antoine Borel, Raouf Amara, Zakaria Said, Marin Tharrault

Thank you for your attention

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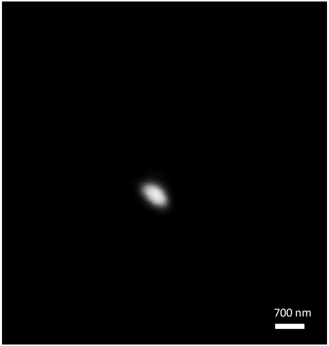
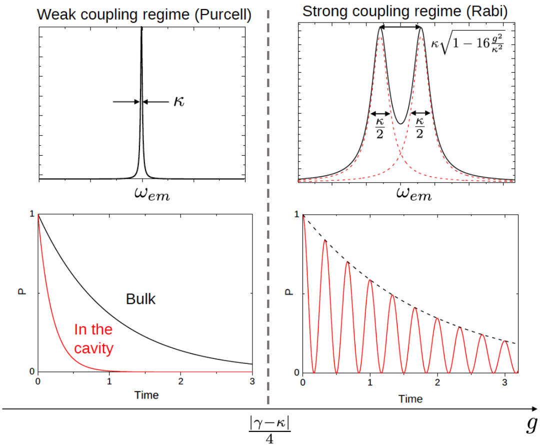
Isolation of single antenna



The strong coupling regime



Raman spectroscopy of CNTs