Master internship (from 02/23) followed by a Ph.D THESIS (from 09/23) with an ANR fundings (NACRI):

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https://coulomb.umontpellier.fr/-Equipe-Nanomateriaux-

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Title: *Hybrid Single Walled Carbon Nanotubes: Study of their Optical and Electronic Properties*

In nanoelectronics and photonics, achieving high-performance devices requires efficient optical-electrical transduction. In this respect, semiconducting single-walled carbon nanotubes (SC-NTs) are prime candidates because of the combination of their exceptional electronic properties (e.g. high carrier mobility, small capacitance) and unique optical response (direct bandgap, tunable optical transitions, highly polarized) associated with their 1D nature. They are easy to manufacture, lightweight, versatile, and solution processable. They open the way to flexible electronic and photonic devices. Contrary to organic molecules commonly used in molecular electronics, the one-dimensional structure of SC-NTs allows the quasi-ballistic transport of electrons and holes even at room temperature. In addition, SC-NTs display optical absorption and emission in the near-infrared which is of particular interest for biological (*e.g.* biotransparency) and technological applications. Functionalizing SC-NTs early appeared as an appealing way to improve nanotube optical properties together with providing new functionalities. In this project (M2 internship & Ph.D thesis), we propose to study at a fundamental level the optoelectronic properties of novel hybrid individual nano-objects made of specifically-designed dyes confined inside SC-NTs with identified structure. Such systems provide a unique model to study the basic optoelectronic properties of chromophores under ultimate 1D confinement and their coupling with those of the host nanocontainer.
Our key objective is the electronic band engineering of hybrid NT in order create (1) nano light-absorbers relying on charge transfer (exciton dissociation at the interface) and (2) electroluminescent emitters relying on energy transfers (exciton transfer in between the two sub-systems).

Scope of the proposed research:

The goal of this thesis is to study the physical interactions taking place in between the confined molecules and the host carbon nanotube and to determine the physical properties of the new smart hybrid nano-systems. The first step will consist in elaborating the hybrid nanotubes. The characterization will be mainly performed by Raman and photoluminescence spectroscopies. Secondly, photo-current and electro-luminescent devices will be prepared using state-of-the-art clean-room technology (e-beam lithography, metallic deposition and lift-off) in order to lead first to photocurrent experiment on encapsulated individual SC-NT or layers, and then electroluminescence experiments. Many other experiments will be performed in collaboration (Transmission Electron Microscopy with CEA Grenoble). The experimental work will also be supported by theoretical calculations.

Applicant:

This project is adapted for a student with a solid background in photonics, optics or fundamental physics. Prior knowledge of carbon nanotube science is not necessary. The thesis involves substantial experimental work for sample preparation and use of free space optical setup, so skills for experimental work are mandatory. A previous experience in clean-room will be a boon. Strong taste for interdisciplinary research and learning new stuff is also essential.