PhD Thesis:

Light energy transport and conversion in organic nanoparticles

Phd Thesis Supervisor: Dr Jérémie Léonard
Institut de Physique et Chimie des Matériaux de Strasbourg, IPCMS
Département d'Optique ultrarapide et Nanophotonique (DON)
Jeremie.Leonard@ipcms.unistra.fr

Light energy collection (i.e. absorption), transport and conversion are fundamental processes at the origin of natural and artificial photosynthesis, photocatalysis, photovoltaic energy conversion, or single molecule detection in biomedical sciences. These processes are commonly performed by so-called nano-antennas, which absorb and transport light energy until the reactive site where energy conversion takes place. While most man-tailored nano-antennas are metallic (plasmonic) nanoparticules, natural nano-antennas, such as those involved in photosynthesis, are organic protein/pigment complexes showing unparalleled performances. In the latter, the pigments are organic dyes which absorb light energy and store it - for a limited time - in the form of molecular excitation energy - i.e. excitons. Energy transport is then achieved by the process of energy transfer - hopping of excitons - from one to another dye. Eventually energy conversion is performed upon energy transfer to a photoreactive molecule. Light energy conversion efficiency is controlled by the fact that energy transport and conversion must occur on time scales faster than the excitons lifetime.

We propose to investigate the fundamental photophysical mechanism of exciton transport and interactions (annihilation) in **synthetic dye-doped, organic nano-particules (ONP's)** specifically designed for biophotonic applications. This work is part of a multidisplinary research program gathering photophysicists - our team at IPCMS-DON - and (bio)chemists – Pharmacy faculty of the Université de Strasbourg. The aim is to unravel both the functional and detrimental photophysical processes at work in synthetic ONP's in order to further optimize their design and enhance their nano-antenna effect [1] or photo-chemical energy conversion efficiency [2]. Depending on the nature of the excitons (singlet or triplet spin character), the characteristic time scales for exciton hoping times or lifetimes may range from femtoseconds (10^{-15} s) to milliseconds. To investigate the dynamics and interactions of singlet or triplet excitons on all time scales in such ONP's, we will apply **time-resolved optical spectroscopy** using a range of techniques including transient absorption spectroscopy, state-of-the-art femtosecond fluorescence up-conversion [3] or 2-dimensionnal optical spectroscopy [4] presently under development in our team.

We offer a 3-year PhD contract and seek a candidate with high motivation to participate to this multidiscilplinary research program. The candidate should have a solid scientific background in physics and optics or in physical chemistry and molecular spectroscopy. Applications should include CV, cover letter and contact information of two references.

[1] K. Trofymchuk et al., "Giant light-harvesting nanoantenna for single molecule detection in ambient light", Nat. Phot. (2017), **11**, 657.
[2] ANR project "LightInDR" (2018-22), https://anr.fr/Project-ANR-18-CE09-0016
[3] Léonard, J, T Gelot, K Torgasin, et S Haacke. « Ultrafast fluorescence spectroscopy of biologically relevant chromophores using type II difference frequency generation ». *J Phys Conf Ser. (2011)* **277**, 012017.
[4] Maiuri, Margherita and Johanna Brazard. "Electronic Couplings in (Bio-) Chemical Processes". *Topics in Current Chemistry* (2018), **376**, 10.