Ultrafast photoreactivity of bio-inspired molecular devices

Open PhD position (36 months) starting in October 2023.
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The molecular scale has become the relevant scale to design new functional materials. This is exemplified by the development of nano-devices called molecular motors [1] that convert light energy into mechanical energy. Also, molecular photoswitches are designed to control with light the structure and function of molecular devices for applications in photopharmacology or nanoscience. Other molecular materials are synthesized for photovoltaic or photochemical energy conversion. The design of light-responsive molecular devices and materials may be inspired by natural, photosensitive biomolecular systems which perform similar tasks with outstanding efficiency.

In such (bio) molecular systems, the light energy conversion is performed by photo-induced chemical reactions. In response to light absorption by the electrons, the nuclei of the molecules enter in motion, eventually resulting in the formation of a new molecular state, i.e. the photoproduct. Also, ultimately, some of the photon energy is dispersed to the environment (e.g. the solvent for molecules in solution). All these physical processes contribute the so-called photoreaction. They typically occur on the picosecond time scale or faster. **Understanding such photophysical processes** is of fundamental interest in the view of designing light-responsive molecular devices with optimum performances. It requires a mutidisciplinary research effort involving chemical synthesis as well as experimental and theoretical investigations of the photoreaction mechanisms. [2]

In this context, we propose a PhD program to investigate these ultrafast photophysical processes **experimentally** by using ultrashort (femtosecond = 10^{-15} s) UV-Vis laser pulses to perform **time-resolved spectroscopy**. The project focusses on **ultrafast C=C double bond photoisomerization in bio-inspired molecular switches or motors** used to convert light energy into mechanical energy at the molecular scale. In particular, by engineering the interaction of a photoswitch with its environment (e.g. via supramolecular encapsulation, in collaboration with organic chemists at IPCMS), we will investigate how the photoreactive vibrational motions may be tuned by chemical design in order to control the photoreaction dynamics and quantum yield. In this project, the PhD student will use and further develop a time-resolved spectroscopy experiment designed to monitor the coherent nuclear motions triggered in the molecular system by a sub-10fs excitation light pulse. [3,4]

To develop this physical chemistry project, we are looking for a motivated candidate, with a training in physics and strong knowledge in nonlinear optics and optical spectroscopy. Applicants should contact Jérémie Léonard by mail with:

- a detailed CV,
- a 1-page cover letter,
- the names and contact information of two referees,
- master grades

[1] Feringa, B.L. Nobel Lecture: The Art of Building Small, from molecular switches to motors, 2016.
[2] Filatov, M. et al. « Towards the Engineering of a Photon-Only Two-Stroke Rotary Molecular Motor ». Nat. Commun (2022) **13**, 6433.
[3] M. Gueye, et al. « Broadband UV-Vis vibrational coherence spectrometer based on a hollow fiber compressor ». Rev. Sci. Instr. (2016) **87**, 093109.
[4] M. Gueye, et al., "Engineering the vibrational coherence of vision into a synthetic molecular device", Nat. Commun. (2018) **9**, 313.