

Master QLMN (Quantum, Light, Materials and Nano Sciences)

Proposition de stage / Internship proposal

Date de la proposition : 20/10/2023

Responsable du stage / internship supervisor:

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Nom du Laboratoire / laboratory name: Laboratoire d'Optique et Biosciences

Etablissement / institution : IP Paris Code d'identification : UMR 7645

Site Internet / web site: <https://lob.ip-paris.fr/en/research/dynamics-biomolecules>

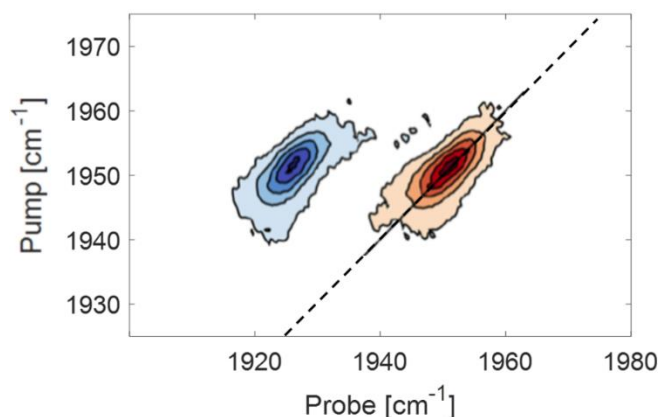
Adresse / address: LOB, Ecole polytechnique, Palaiseau, France

Lieu du stage / internship place: Ecole polytechnique et Institut d'Optique

Titre du stage / internship title: Femtosecond two-dimensional infrared spectroscopy in CO₂ and in hemoglobin

Résumé / summary

Laboratoire d'Optique et Biosciences (LOB) benefits from a cross-disciplinary environment where physicists and biologists work together in order to address relevant issues in biology through the development of new optical methods, based for example on femtosecond lasers and nonlinear optics. In this context, the host team is more particularly developing femtosecond spectroscopy in the mid-infrared (MIR) in order to control and probe molecular vibrations in biomolecules such as hemoproteins [1, 2] or photoenzymes [3]. One of the methods developed at LOB is Fourier-transform two-dimensional infrared (2DIR) spectroscopy. It consists in measuring a pump-probe spectrum which is frequency resolved in both pump and probe dimensions, allowing to monitor the coupling between different vibrational modes. It is also sensitive to protein structure fluctuations, as in the example shown to the left in the case of carboxyhemoglobin [4]. The elongation along the diagonal is a signature of inhomogeneous broadening due to a distribution of protein structures, whose evolution can thus be monitored as a function of time.



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In collaboration with Laboratoire Charles Fabry (IOGS) and the Amplitude company, we have recently developed within the MIRThyX project a new two-dimensional infrared spectrometer of unprecedented spectral resolution, thanks to a nonlinear optical method coined Chirped Pulse Upconversion allowing direct detection of MIR radiation with a visible CMOS camera. The proposed internship will consist in applying this new experiment to recording 2DIR spectra in carboxyhemoglobin and in carbon dioxide. In the latter case, the 2DIR spectrum will exhibit a large number of narrow lines associated to different rotational modes, thus evidencing the remarkable spectral resolution that can be achieved in both pump and probe dimensions. The experimental results will be compared with a numerical calculation based on a quantized rigid rotator model for calculating the 2D rovibrational spectrum.

- [1] P. Nuernberger, K.F. Lee, A. Bonvalet, L. Bouzahir-sima, J.C. Lambry, U. Liebl, M. Joffre, M.H. Vos, *J. Am. Chem. Soc.* **133**, 17110 (2011).
- [2] V. Kemlin, A. Bonvalet, L. Daniault, M. Joffre, *J. Phys. Chem. Lett.* **7**, 3377 (2016).
- [3] D. Sorigué et al., *Science* **372**, eabd5687 (2021).
- [4] C. Falvo, L. Daniault, T. Vieille, V. Kemlin, J.C. Lambry, C. Meier, M.H. Vos, A. Bonvalet, M. Joffre, *J. Phys. Chem. Lett.* **6**, 2216 (2015).

Ce stage pourra-t-il se prolonger en thèse ? Possibility of a PhD ? : YES

Si oui, financement de thèse envisagé ou acquis / financial support for the PhD ?

Financement acquis / Secured funding	Nature du financement / Type of funding	
Financement demandé / Requested funding	Nature du financement / Type of funding	Alloc. Doctorale