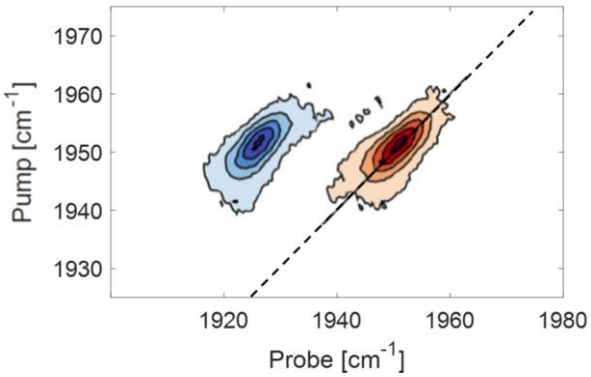
INTERNSHIP PROPOSAL

Laboratory name: Laboratoire d'Optique et Biosciences
CNRS identification code: UMR 7645
Internship director'surname: Manuel Joffre
e-mail: manuel.joffre@polytechnique.edu Phone number: 0169335042
Web page: lob.ip-paris.fr/en/research/dynamics-biomolecules
Internship location: Ecole polytechnique, Palaiseau, France

Thesis possibility after internship: YES
Funding: NO (application to Ecole Doctorale IP Paris)

Femtosecond two-dimensional infrared spectroscopy in carbon dioxide and hemoglobin

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.



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 diodixe. 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. Bouzhir-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).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: YES