Laboratoire d'Optique et Biosciences
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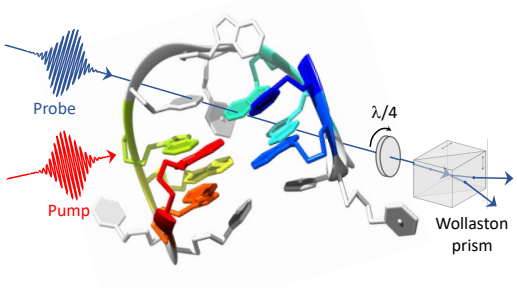
Internship proposal

Development of single-shot balanced detection for femtosecond circular dichroism

Circular dichroism (CD) is the property of chiral molecules to absorb differently left- and right-circularly polarized light. CD spectroscopy is a very popular technique for analyzing the secondary structure of biomolecules at equilibrium in solution. However, despite the conceptual simplicity of static measurements, their transposition to the time domain (TRCD), especially on the sub-picosecond time scale, remains challenging due to their weak signals prone to pump-induced polarization artifacts. In this context, the Laboratory for Optics and Biosciences has been developing chirality-sensitive pump-probe methods for the study of the conformational dynamics of biomolecules over an extended time domain ranging from femtoseconds to seconds, for more than a decade.[1,2] The basic principle of pump-probe spectroscopy relies on the measurement of the third order non-linear optical response of a medium following the interaction of a first strong laser "pump" pulse, which is used as the perturbation to trigger a photoinduced reaction and a second weaker "probe" pulse used to monitor the pump-induced changes. Recently we have developed a simple and robust method allowing simultaneous measurement of the intensity variation of the two circular polarization components of linearly polarized probe pulses.[3] This balanced detection geometry allows femtosecond TRCD signals to be recovered from a single laser shot, which significantly increases S/N ratio and reduces the acquisition times.



Principle of balanced detection configuration for femtosecond TRCD measurements

The objective of this internship will aim at implementing this detection over an extended spectral region spanning the visible down to the deep-UV and then to test its potentiality for the measurements of relevant chiral model systems. In this respect, a commercial 1kHz amplified Ti:sa laser source delivering 800-nm pulses of 100-fs duration will be used. Pump and probe will be generated from the combination of optical parametric amplification, sum frequency generation and second harmonic generation, allowing a tunability over 220 nm up to 700 nm.

We are looking for a motivated candidate to develop this experimental project at the interface of physics and biology, with strong knowledge in non-linear optics and computer science (Python). Basic knowledge of ultrafast spectroscopy will be an additional asset. The project will take place in the "Internal dynamics of biomolecules" group at the Laboratory for Optics and Biosciences. The team has a well-known expertise in the field of non-linear optics and ultrafast chiroptical spectroscopy. The work will be supervised by Pascale Changenet and François Hache (CNRS researchers).

Recent publications:

[1] Hache F. and Changenet P., Multiscale conformational dynamics probed by time-resolved circular dichroism from seconds to picoseconds, *Chirality* (2021) 33, 747.
[2] Schmid M., Martinez-Fernandez L. et al., Unveiling excited-state chirality of binaphthols by femtosecond circular dichroism and quantum chemical calculations, *J. Phys. Chem. Lett.* (2019) 10, 4089.
[3] Changenet P., Hache F., Artifact-free balanced detection for the measurement of circular dichroism with a subpicosecond time resolution, *Opt. Express* (2023) 31, 21296.

Website: https://lob.ip-paris.fr/recherche/dynamique-des-biomolecules/protein-and-dna-folding-dynamics-probed-time-resolved-circular-dichroism

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Possibility for a PhD : Yes