# Second harmonic scattering study of DNA nanostructures :

# From single nucleobases up to single stranded DNA

**PROPOSAL FOR A M2 INTERNSHIP IN NONLINEAR OPTICS (possible continuation in PhD)**

**Laboratory :** Institut Lumière Matière (ILM), Equipe Optique Non Linéaire et Interfaces, Université Claude Bernard Lyon1, 43 Boul. du 11 novembre, 69622 Villeurbanne.

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DNA is the biomolecular system encoding the genetic instructions used in the development and functioning of living organisms. It is composed of four different nucleobases, namely Adenine (**A**), Thymine (**T**), Cytosine (**C**) et Guanine (**G**). They bind with hydrogen bonds into pairs as A-T and C-G providing to DNA a well defined structure known as its sequence. Recently, DNA has been investigated from the point of view of nonlinear optics and second harmonic generation (SHG) in particular, due to the pseudo-phase matching condition arising from the double helical structure.

SHG is a nonlinear optical process entailing the conversion of two photons at a fundamental frequency into a single one at the harmonic frequency. It has attracted interest due to the wide applications, notably in biological studies for bio-imaging for instance as well as in cancer research studies. SHG signals can indeed be used as optical indicators of biochemical and/or biophysical events occurring in DNA like cleavage.

**Second-Order Hyperpolarizability**

The cross-section for the SHG process of a molecular compound is known as the first hyperpolarizability and can be determined through SHG scattering experiments also known as Hyper Rayleigh Scattering (HRS) experiments. Hence, in order to ultimately understand the build-up of the first hyperpolarizability of a dual helical structure, we propose to investigate in a first step single stranded DNA (ssDNA) and its constitution from the different arrangements of the four nucleobases. Preliminary results have already yielded the first hyperpolarizability of two of the four bases. With a similar method, we will determine the first hyperpolarizability of short synthetic oligonucleotides with different sequences. The strategy will focus on the potential cross-talk between the different bases in order to test the additive model that has been successful in determining the first hyperpolarizability of proteins from their amino acid sequence.

**Polarization-Resolved HRS Experiments.**

In order to deepen this study, we will also gain insight into the geometrical arrangement of the oligonucleotides using polarization resolved HRS. It is known indeed that this method reveals fine details of the three-dimensional spatial organization of molecular compounds acting as sources to the SHG signal. One of the objectives of these measurements will be here to unravel the spatial geometry of the oligonucleotides and the rigidity of the oligonucleotides as a function of their length.

The last step of the study will then be devoted to the determination of long single-stranded DNA in order to push the additive model to long DNA sequences.

**Pursuit in a PhD program**

This work can be extended as a PhD subjected to funding.