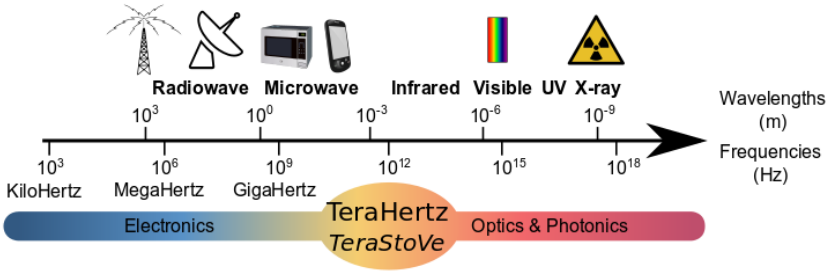
THz Metasurface for Light Matter Interaction Enhancement in Biomolecules

CONTEXT

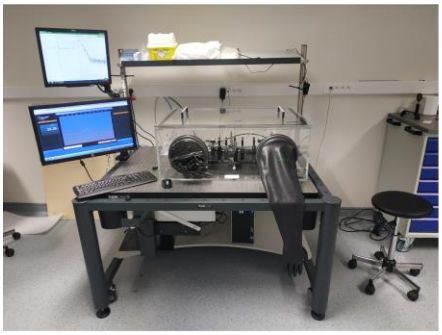
During the XVI th century, a controversy between D'Alembert, Euler and Bernoulli highlighted the study of resonant vibration of objects. This gave rise to numerous consequences at different scale until today. Specifically, it made the link between the size of an object and its vibration frequency: from the vibration of the earth mantel, the string of a violin down to molecular bonds probed through infrared spectroscopy. For our purpose, it is extremely useful and important that the vibration frequency of an object of the size of macromolecules lies in the terahertz range (THz: 0.1 to 10 THz). This is a band of the electromagnetic spectrum lying between optics and microwaves revealing the properties of both these regions. THz waves have the striking capability of revealing the composition of a target. Many complex composites such as explosives, or bio-matter like proteins, amino acids and DNA, exhibit specific vibrational dynamics when excited by THz fields – this fact has caused a strong interest in THz spectroscopy.

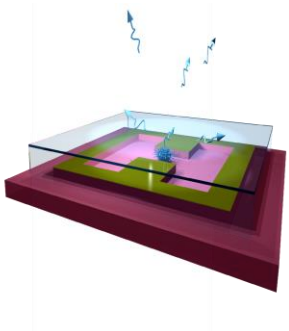


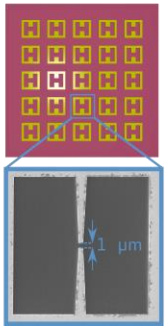
The study of the THz range is one of the most attractive since it takes the full benefit of recent progress in system performances (emitters, sensors) and at the same time employs the recent advances in nanotechnology. This opens a door for applications in security, biology and medicine where the THz range has a capability unreachable by other frequency ranges leading to new technics and methods of diagnostics and treatment. However, the THz study of organics is still limited mostly because of the size of a biological object (bacteria, cell, virus…) much smaller than the one of the wavelength in the THz range. Therefore, their interactions with the THz photons are very weak making the experiments on a sample of volume bellow 1 microliter extremely challenging.

GOALS

This PhD project will complement our efforts to provide a THz spectroscopy method implying the enhancement by a specially designed metastructure to study biological macromolecules, in particular viruses. The idea is: 1) to enhance the light mater interactions using a micro/nano photonic approach in the THz range to confine the light and the sample in a very small volume; 2) to optimize a time-domain-spectroscopy system to increase the performances in the specific case of small biological samples; 3) to follow a pluridisciplinary research in order to adapt the system, the experimental method and the data analysis for biological samples. The final goal is to enable the measurement of vibration of the viral particle to reveal its physicochemical properties. The results will allow to answer the fundamental question in virology as well as to get a step further in setting up new technics for measurements during vaccine production and conservation.







MISSION

This research work includes a first part of photonic design and simulation, a second one to fabricate the device and the most important one consisting in the setting up and performing THz spectroscopy experiments on biological samples. Finally, the results will be interpreted with a threefold point of view: electromagnetic (field enhancement), physic (vibrations) and biological.

ENVIRONEMENT

The PhD study will be mainly done within the THz-Photonics group of the IEMN CNRS (Lille 1 University campus in Villeneuve d'Ascq, France, easily reachable in 15 minutes from Lille city center by subway). The institute disposes of 2000 m^2 of modern clean room facilities and the group operates state-of-the-art tools for THz characterization. Moreover, the virology lab of our collaborators are also located in Lille metropole, thus everything is within arm's reach making the work extremely convenient. Indeed, further international partnership will be engaged and conferences will be attended during the PhD.
A number of training opportunities is available within the clean room of IEMN and by Lille 1 University.

FUNDINGS

This PhD work is fully funded by the pluridisciplinary project TeraStoVe (collaboration between the IEMN CNRS institute and a virology lab of the university hospital of Lille) in the frame of the "Expand" program of the I-Site "Université Lille Nord Europe" with the objective to expand the excellence perimeter of the university. The competitive PhD candidate's salary is granted for 3 years.

Practical information

Starting date:
October 2018. However, the slight shift is possible.

Application deadline:
15 July 2018.

Application: We are looking for a highly motivated (enthusiastic) and qualified PhD candidate holding (or completing soon) a Diploma, ME or MSc degree in Physics, Biophysics, Optical or Electronic Engineering. The motivated applicants with a degree in Programming, Chemistry and Biology will also be considered.
One or several of the following skills are highly desirable but are not a must, as we will first look for a motivated pragmatic scientist:

Experimental optics, electromagnetism, microfluidics, spectroscopy, microbiology.

The applications should include a CV, a motivation letter as well as at least two reference contacts.

Contacts: The applicants are welcome to contact the Biophotonics activity team composed of:

- Dr. Romain Peretti romain.peretti@iemn.univ-lille1.fr
- Dr. Sergey Mitryukovskiy Sergey.Mitryukovskiy@iemn.univ-lille1.fr
- Dr. Jean-Francois Lampin jean-francois.lampin@iemn.univ-lille1.fr (head of the Thz group)

Note that informal enquiries on the PhD project and our work before any formal application are very welcome.

KEYWORDS

Terahertz, metamaterials, spectroscopy, biophotonics, virus.

FURTHER READING

- https://photoniquethz.iemn.univ-lille1.fr/en/
- https://en.wikipedia.org/wiki/Terahertz_time-domain_spectroscopy
- http://www.mdpi.com/2304-6732/5/2/11
- https://aip.scitation.org/doi/full/10.1063/1.5007681