Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Bio-photonic sensors based on metamaterials

Supervisor : : Emmanuel Centeno
Laboratory : Institut Pascal
University : Clermont Auvergne
Email and Phone : emmanuel.centeno@uca.fr
Possible co-supervisor : Rafik Smaali
Laboratory : Institut Pascal - Photon
University : Clermont Auvergne

Summary :
Biological or chemical molecules identification and concentration measurements is an area in which photonics provides original and effective solutions in terms of sensitivity and detection limit [1]. The weak interaction of light with molecules is the most important issue of the optical approach. Plasmonics tackles this problem by using surface or localized plasmons-polaritons that confine and increase the electromagnetic field around the molecules. Recent works demonstrate that hyperbolic metamaterials (HM) may overcome the current limits of plasmonic systems [2].

The "Electromagnetism and Nanophotonics" team of the Photon laboratory at Pascal Institute is recognized for its theoretical work in the fields of plasmonics and metamaterials. In particular, we recently developed the concept of hyperbolic antennas, which are ten times smaller than conventional plasmonic antennas [3].

The aim of the thesis is to study the properties of metasurfaces based on hyperbolic antennas for the design of efficient bio-photonic sensors. These electromagnetic modeling and simulations will define the ultimate performance of these new sensors.

The PhD student will develop theoretical models and perform electromagnetic simulations of sensors based on metamaterials. He (she) must have good knowledge in electromagnetism, semiconductor physics and programming.

References :

[1] Mejía-Salazar, J. R., and Osvaldo N. Oliveira Jr. "Plasmonic biosensing: focus review." *Chemical reviews* **118**, 10617 (2018).
[2] Pan Wang, M. E. Nasir, A. V. Krasavin, W. Dickson, Y. Jiang, and Anatoly V Zayats, “Plasmonic Metamaterials for Nanochemistry and Sensing,” *ACCounts of Chemical Research* **52,** 3018 (2019). [3] R. Smaali, F. Omeis, A. Moreau, E. Centeno, T. Taliercio, « Miniaturizing optical antennas using hyperbolic metamaterial wires », *Physical Review B* **95,** 155306 (2017).