INTERNSHIP + PhD THESIS PROPOSAL with financial support (2019)

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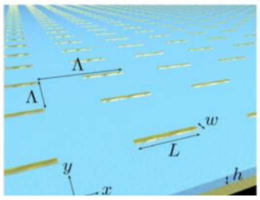
Thesis possibility after internship: YES

Funding: Internship is paid, and half the PhD fellowship is already available from ONERA, and will be consolidated by a second half (DGA, Labex, ONERA, or ED PIF).

FROM THE NEAR FIELD OF NANO-ANTENNAS TO THE FAR FIELD OF INFRARED METASURFACES



Metasurface made of an array of nano-antennas

Developments in nanostructuring capabilities has led to fascinating effects in optics and electromagnetism such as black gold, invisibility, negative refraction, or thermal radiation cooling [1]. Metasufaces made of arrays of cleverly designed nano-antennas allow one to tailor the optical response of a surface (reflectivity, absorption, transmission) while requiring only a surface texturing with a thickness of 1/100 of the wavelength. It is possible to produce a surface which is perfectly absorbing at selected wavelengths, while being reflecting in other regions of the spectrum. The main challenges are now to tailor the spectral, angular, and polarization responses with a higher level of complexity for applications such as infrared detection, stealth, radiative cooling, etc. This requires to design and organize nano-antennas to produce a metasurface with an optimized measurable response in the far field. The most classical way is to produce a periodical array, but some applications require to suppress any signature of a grating in the far field response, or to optimize the interaction between the nano-antennas, and thus to control their near-field properties. **To reach this goal, it is crucial to study the behavior of single nano-antennas or the near-field interactions within a small group of nano-antennas.**

We have shown that we are capable to characterize the electromagnetic properties of a single nano-antenna in the infrared by measuring its thermal emission, both in the near field and in the far field using super-resolved imaging and spectroscopy [2, 3] and a recently developed method of infrared spatial modulation spectroscopy [4].

The PhD project that we propose will be to deepen our knowledge of the parameters which control the electromagnetic response of single nano-antennas, and to investigate how such electromagnetic nanometer-sized resonators couple together when they are placed in near-field interaction. The research activities of the student involve conception and modeling, the development of novel experimental techniques, and the experimental near-field and far-field measurements of systems with single or a small number of coupled antennas.

The proposed research project will be developed within a collaboration between Institut LANGEVIN (ESPCI Paris) and ONERA/DOTA, The French Aerospace Agency (Patrick Bouchon and Riad Haidar). The student will benefit of complementary competences from the two institutes: Institut LANGEVIN develops unique near-field and far-field investigation methods, and ONERA/DOTA has high competences in electromagnetic modeling and device fabrication.

REFERENCES:

[1] Y. De Wilde and R. Haidar, NATURE, **566**, 186 (2019).
[2] Y. De Wilde et al., NATURE, **444**, 740 (2006).
[3] A. Babuty et al., PHYSICAL REVIEW LETTERS, **110**, 146103 (2013).
[4] C. Li et al., PHYSICAL REVIEW LETTERS, **121**, 243901 (2018).

Methods and techniques: Advanced infrared microscopy and spectroscopy methods at sub-λ scales, electromagnetic modeling and conception of nano-antennas.