INTERNSHIP PROPOSAL

(One page maximum)

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Thesis possibility after internship: YES
Funding: YES and NO If YES, which type of funding: EDPIF, Labex WIFI, CDSN

Digital holography in non-linear regime for the investigation of nanostructures

Digital holography is an imaging technique that enables a 3-dimensional reconstruction of the electromagnetic field scattered by an object in both amplitude and phase. We demonstrated its use in microscopy for the full 3-D mapping of the field scattered by single nanostructures such as nano-antennas [1] and near-field probes [2]. Holography is an interference process, which can be obtained at the laser illumination wavelength, but also with Second Harmonic Generation (SHG) since it is produced in a coherent process [3].

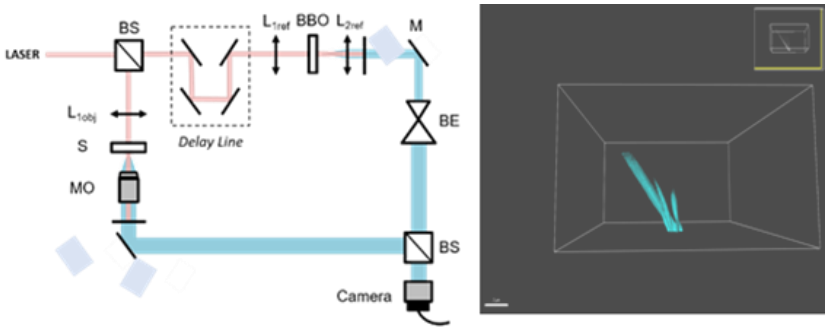
We propose to pursue the development of a harmonic holographic microscope for single-shot mapping of the second harmonic 3D radiation pattern near samples with nonzero second harmonic susceptibilities. The knowledge of the scattered field (amplitude and phase) in a given plane (that of the camera) allows its reconstruction in any other plane using e.g. the angular spectrum representation of optical fields [4], and assuming propagation in homogeneous media, a process called 3D numerical back-propagation [5].

In addition to providing 3D reconstruction, thus enhancing the imaging capabilities beyond those of back focal-plane imaging, the harmonic holography microscope also benefits from an amplification effect since the signal from the sample is multiplied by an intense reference in the interference term, making the method particularly well suited to measure the weak SHG signals produced by metallic nanostructures.

After a first validation on dielectric samples made of nonlinear micro-crystals and cornea collagen, we are currently implementing it to unravel the SHG field radiated by nanostructures such as plasmonic nano-antennas and non-linear resonant structures.

The training will be performed under supervision of Yannick De Wilde (CNRS Research Director at Institut Langevin scientist) and co-supervision of his PhD student Serena Goldmann and our collaborator Gilles Tessier (Professor at Sorbonne University). We plan to continue it with a thesis.

Figure: Non-linear digital holographic setup and reconstruction of the field radiated by a microstructure.



References: **[1]** S. Suck *et al.* Optics Letters, 36, 849−851 (2011) **[2]** N. Rahbany *et al.* ACS Photonics, 5, 1539-1545 (2018). **[3]** E. Shaffer *et al.* Optics Letters, 34, 2450-2452 (2009) **[4]** L. Novotny and B. Hecht. Principles of Nano-optics. 2006. Cambridge University Press. **[5]** C. Hu *et al.*. Nature Photonics 14, 564–569 (2020).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: NO