INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de physique de l'Ecole Normale Supérieure (LPENS)
CNRS identification code: UMR8023
Internship director'surname: Carlo Sirtori (LPENS) & Angela Vasanelli (LPENS)
e-mail: carlo.sirtori@ens.fr, angela.vasanelli@ens.fr
Internship location: LPENS, 24 rue Lhomond, 75005 Paris

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Phase modulators for free-space optics in the mid-infrared

An electro-optic modulator is a device allowing the modulation of a beam of light by means of an applied electrical signal. The modulation can be imprinted on different properties of the light beam: amplitude, phase, frequency or polarization of the beam. They are essential in several applications like telecommunications, image projections, displays. Phase modulators are extremely important in quantum technologies: they are used to produce entangled light states in photonic platforms, or to optically address and/or prepare quantum bits.
While they are commercially available in the visible and near-infrared range, electro-optic modulators are at their infancy as far as mid-infrared wavelengths are concerned. Recently, our group has developed an amplitude modulator based on the Stark effect in a system of tunnel coupled quantum wells. This device allowed us to realize a data transmission experiment in the free-space, with record bitrate.[1,2]

The aim of this project is the realization of phase modulators in the mid-infrared.[3,4] Such devices will be implemented in a waveguide geometry, and they will be exploited to realize a Mach-Zehnder interferometer. Combined with a sensitive mid-infrared detector, such interferometer would be the first building block for a fully integrated heterodyne detection [5] platform, opening the path towards extending the realm of quantum optics towards the mid-infrared domain.

The PhD thesis is financed by an ANR project.

References

[1] T. Bonazzi, et al., Metamaterial unipolar quantum optoelectronics for mid-infrared free-space optics, APL Photonics (2024).
[2] H. Dely, et al., 10 Gbit s^{-1} Free Space Data Transmission at 9µm Wavelength With Unipolar Quantum Optoelectronics, Laser Photonics Rev. 16, 2100414 (2022).
[3] H. Chung, et al., Electrical Phase Modulation Based on Mid-Infrared Intersubband Polaritonic Metasurfaces, Adv. Sci. 10, 2207520 (2023).
[4] H. Dely, et al., Heterodyne coherent detection of phase modulation in a mid-infrared unipolar device, Optics Express 31, 30876 (2023)
[5] M. Saemian, et al., Ultra-sensitive heterodyne detection at room temperature in the atmospheric windows, Nanophotonics 13, 1765 (2024)

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

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