INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de physique de l'Ecole Normale Supérieure (LPENS)
CNRS identification code: UMR 8023
Internship director'surname: : Carlo Sirtori & Baptiste Chomet (LPENS)
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Internship location: 24 rue Lhomond, 75005 Paris
Thesis possibility after internship: YES
Funding: YES

Title Nano-laser arrays for quantum sensing in the mid infrared ($\lambda \sim 10\mu m$)

The Quantum Physics and Devices group at ENS is looking for a highly motivated student for a 3-year PhD project in the field of Quantum Optoelectronics. The objective of the PhD research project is to realise an array of quantum cascade (QC) nano-lasers by conceiving a photonic structure that merges concepts from microwave and optics. Indeed, concepts from the microwave range based on antenna theory could be implemented at much higher frequencies to spark new hybrid devices merging optics and electronics, dielectric and metals. Metallic antennae will be used to realise microcavities to enhance light-matter interaction and produce light emission.[1,2,3,4] In particular patch-antennae will be adapted to produce an array of QC lasers that contribute to produce a coherent collective mode with substantially new performances in terms of wavelength engineering, spatial beam properties and low energy consumption. The properties of this photonic structure will be a mean to explore the quantum properties of the emitted light.

The PhD candidate will have the opportunity to work in a dynamic scientific environment of research excellence in the heart of Paris.

The first year will be focused on the demonstration of light emission at λ = 10 µm from a patch antenna device. The PhD candidate will carry out the nano-fabrication process in the ENS and University Paris Cité clean rooms and conduct electrical and optical characterization of the samples. Once the laser action is demonstrated, the second year will be dedicated to the conception of patch antenna arrays for the generation of mid-infrared light with advanced functionalities. During the third year, the PhD candidate will investigate the quantum properties of the light emitted from the patch antenna devices by using experimental set-ups based on coherent detection schemes.

References

1. A. Delteil, A. Vasanelli, Y. Todorov, C. Feuillet-Palma, M. Renaudat St-Jean, G. Beaudoin, I. Sagnes and C. Sirtori, *Charge induced coherence between intersubband plasmons in a quantum structure*, Phys. Rev. Lett. 109, 246808 (2012).
2. D. Palaferri, Y. Todorov, A. Bigioli, A. Mottaghizadeh, D. Gacemi, A. Calabrese, A. Vasanelli, L. Li, A; G. Davies, E. Linfield, F. Kapsalidis, M. beck, J. Faist, C. Sirtori, *Room temperature 9µm photodetectors and GHz heterodyne receivers*, Nature 556, 85–88 (2018).
3. J. Madéo, Y. Todorov, A. Gilman, G. Frucci, L. H. Li, A. G. Davies, E. H. Linfield, C. Sirtori, K. M. Dani, *Patch antenna microcavity terahertz sources with enhanced emission*, Appl. Phys. Lett. 109, 141103 (2016).
4. J. Pérez-Urquizo, Y. Todorov, L.H. Li, A. G. Davies, E. H. Linfield, C. Sirtori, J. Madéo, K. M. Dani, *Monolithic Patch-Antenna THz Lasers with Extremely Low Beam Divergence and Polarization Control*, ACS Photonics 8, 412 (2021)