Quantum Transport and Optics Theory Projects

Postdoc and PhD student search.

Principal Investigator: M.F. Pereira

Collaborators: Theory: A. Apostolakis. Experimental Verification: Superlattices: V. Anfertev, V. Vaks; QCLs: mirSense

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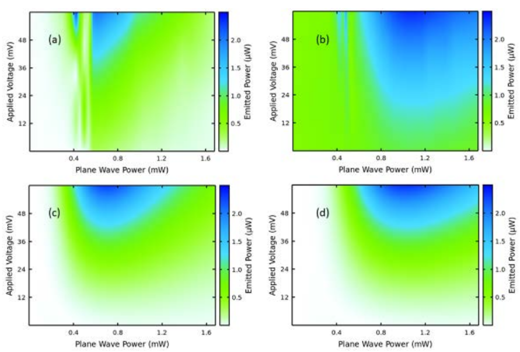

This figure illustrates the experimental demonstration of voltage and power control of nonlinearities. Measured (a, b) and calculated (c, d) [fourth (a, c) and sixth (b, d) harmonics] emitted powers for an input field oscillating at ν=120 GHz. The input and output power detected by our heterodyne technique have been calibrated by simulated annealing as explained in the methods section, from M.F. Pereira et al, Sci Rep 10, 15950 (2020).

Khalifa University (KU): postdoc (2 years) + phd student (4 years – co-funded by KU)
Funding sources: start up grant (approved); CIRA (submitted); ADEK (submitted)

Department of Physics, Institute of Physics of the Czech Academy of Sciences (FZU)
Funding source: H2020, ODYSSEUS project. Postdoc (2 years)

Quantum Cascade Laser and Detector Simulator

KU - The project involves development of software tools to design and simulate the behaviour of quantum cascade lasers (QCL's) working in terahertz and mid-infrared frequencies. The theory and simulations will go beyond our existing previous efforts and will be based on the Nonequilibrium Greens Functions Method [1-5].

FZU (ODYSSEUS) – The simulations will be used to address the following issue:

Detect potential threats in identified areas of interest, including detection of HMEs at the manufacturing stage. Towards the detection of clandestine labs, ODYSSEUS will design, develop and test novel sensors for monitoring sewerage systems in order to detecting intermediates and impurities associated with the manufacturing process, together with air emissions from targeted areas. In particular, ODYSSEUS will adapt and optimise detectors for (i) gas phase precursor detection and identification by advancing GC-PID (Gas Chromatography - Photo Ionization Detection) methods, and (ii) substance detection in water in (near) real time by combining and advancing state-of-the-art vaporisers, ***quantum cascade lasers (QCLs) and photo-acoustic detectors.***

Controllable GHz-THz Nonlinear Optics in Semiconductor Superlattices with Applications to Noninvasive Medical Diagnostic Sensors

KU - Optical nonlinearities are of perpetual importance, notably connected with emerging new materials. Achieving a strong nonlinear response in the microwave to far-infrared spectral ranges is important for the development of GHz-THz technologies e.g. for noninvasive screening medical applications. Nonlinearities in semiconductors are well understood in near infrared and visible ranges, but little is known about the nonlinear response in the GHz and THz regime. Our aim is to deliver a state of the art simulator of intersubband transport and optical response of superlattices, based on Nonequilibrium Green's Functions calculations, coupled with exact solutions of the corresponding Boltzmann equation. This will enable us to design structures with large nonlinear response controlled by external parameters. Prospective structures will be fabricated by Molecular Beam Epitaxy and characterized using spectroscopic, electrical transmission electrical microscopy and electron tomography measurements, thus providing a feedback for the simulator development. We will gain a deep understanding of microscopic phenomena underlying the nonlinearities and provide guidelines for designing components with application potential, such as frequency multipliers. The resulting optimized devices will be used in a spectrometer developed by our collaborators for breath analysis, which is a noninvasive medical screening applications with strong potential for early detection of respiratory diseases such as covid-19, before it becomes symptomatic. The resulting devices also have potential for water quality control. Water masks the sensitive spectroscopic detection of most dangerous substances and we will design our multipliers to operate in one the few GHz-THz low absorption windows of the water spectrum [6-8].

References

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