GIGA-TERA-MIR Quantum Transport and Optics

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This talk starts by highlighting the main goals and achievements of the **TERA-MIR network** [1] along our main lines of research: Intersubband materials and devices with applications to fingerprint spectroscopy; Metamaterials, photonic crystals and new functionalities; Nonlinearities and interaction of radiation with matter including biomaterials; Generation and Detection based on Nitrides and Bismides. **The focus will be on the devices developed.**

Next, my own recent research is summarized: **The α-factor** of intersubband lasers was initially expected to be zero. However, values ranging from -0.5 to 3 have been found experimentally. Starting from a general Nonequilibrium Green's Functions (NEGF) approach suitable for both interband and intersubband optics, the equations are simplified in the intersubband case to a limit that resembles the usual two-level atom approach typically used in Quantum Optics and the nonzero α-factor is explained [2]. **Luminescence** is one of the most important characterisation tools of semiconductor materials and devices. Recently, a very efficient analytical set of equations has been applied to explain optical properties of dilute semiconductor materials, with an emphasis on the evolution of peak luminescence gain with temperature and its relation to sample quality and it will be explained here and presented as a numerical characterization tools, notably useful for materials for the MIR and NIR ranges [3-6]. Evolving from the MIR to the THz and GHz ranges, the talk gives highlights of the **coupling of THz radiation with intervalence band transitions in microcavities** [7] introduces a concept to study nonlinear optics through **controllable nonlinearities in semiconductor superlattice**s [8-9]. These results open the possibility of extending the whole field of **nonlinear optics to the GHZ-THz range** and the possibility of designing materials and devices for a large number of applications, including spectroscopy of biomolecules, which typically have strong GHz-THz resonances.

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Short Biography: Prof. Mauro Fernandes Pereira obtained his PhD at the Optical Sciences Center, University of Arizona and has given important contributions to Nonequlibrium Greens Functions (NEGF) Many Body Theory of Transport and Optics of Semiconductor Materials and has been named SPIE Fellow in 2011 for his contributions to the Theory of Semiconductor Materials and Optics. He created the TERA-MIR concept unifying THz and Mid Infrared Radiation and is the Chair of COST ACTION MP1204: TERA-MIR Radiation: Materials, Generation, Detection and Applications, Chair of the Series of NATO TERA-MIR Conferences (2009, 2012 and 2015). He was a research associate at CBPF, Uni-Rostock and TU-Berlin, a visiting Lecturer at Uni-Bremen, Associate Professor (Professor Adjunto) at Universidade Federal da Bahia, Senior Researcher at Tyndall Institute, Chair of Theory of Semiconductor Materials and Optics at Sheffield Hallam University (2006-2017) and he is now Head of the Department of Condensed Matter Theory at the Institute of Physics of the Academy of Sciences of Czech Republic.