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The THz Spectral Range: a Window of Opportunities

Luigi Consolino[1,2], Alessia Sorgi[1,2], Roberto Eramo[1,2], Francesco Cappelli[1,2], Paolo De Natale[1,2]
[1]*CNR-INO – Istituto Nazionale di Ottica, Largo Enrico Fermi 6, 50125 Firenze FI, Italy &*
[2]*LENS – European Laboratory for Non-Linear Spectroscopy, Via N. Carrara 1, 50019 Sesto F. FI, Italy*
luigi.consolino@ino.cnr.it

We are witnessing impressive progress in THz technologies, mostly driven by the promise of brand new application areas and different ways to interact with matter or to transmit information. Such progress is also related to the under-exploitation of a significant part of the electromagnetic spectrum represented by the far-infrared/THz region that borders with microwaves around 300 GHz and with mid-infrared, around 10 THz or even higher frequencies [1,2]. On the other hand, the potential role of novel photonics tools in the THz range is still to be unveiled but many important applications have already shown its importance. Indeed, material transparency/opacity to THz frequencies is different form nearby mid-IR and can provide better resolved information than lower frequency microwaves/RF [3]. Moreover, for transmission of information THz frequencies are the logical continuation of moving to higher and higher frequencies to get carriers able to carry more and more data [4]. In terms of interaction with matter, THz photons are the key to excite the rotational degrees of freedom of a large part of molecules, enabling metrological measurements to unveil new physics or also to control molecules in view of the most demanding applications on the horizon, like ultracold molecules for quantum simulation, sensing or computing [5,6].

In these really exciting and thrilling times for THz science and technology, it is crucial to invent proper instruments and techniques for unveiling the basical physical mechanisms of new devices, to get reliable measurements of relevant parameters and to sharpen the tools for specific and demanding applications. This has been the main stream of our group in Firenze in the last 35 years and we will review the latest achievements related to state-of-the-art techniques and applications. In particular, efforts have been directed to setting up an heterodyne technique to characterize the newly generated comb patterns, also in QCLs [7,8] and to demonstrate full phase-locking of THz QCL combs [9,10]. More recently, we are further sharpening our photonic techniques to better understand the role of novel architectures and materials in modifying QCL emission [11]. In view of extending the generation domain of THz sources beyond the 5 THz transparency limit of semiconductors routinely used for QCLs fabrication, we demonstrated all telecom-wavelength pumped cw THz generation with simultaneous high resolution and broadband coverage up to about 7.5 THz [12,13]. Finally, we will show novel applications that are emerging from such impressive THz progress, e.g. a novel communication system at THz frequencies [14].

The Materials and Methods should be described with sufficient details. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

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