Room-temperature source of continuous-wave radiation up to 7.5 THz based on telecom technology for high precision spectroscopy

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The terahertz (THz) spectral window, that is generally considered to span from 1 to 10 THz, is nowadays crucial for plenty of every-day-life and scientific applications, as homeland security, environment monitoring, quality inspection of food and biomedicine.

Among these applications, high precision THz spectroscopy of rotational and ro-vibrational molecular transitions promises to deliver many novel physical insights. But, despite its primary importance, a considerable technological gap still separate this region from the rest of the electromagnetic spectrum. In particular, the lack of room-temperature sources and detectors makes high-precision frequency measurements of molecular transitions an open challenge.

Although recent technologies (as frequency multipliers, photo-mixers and quantum-cascade-lasers) already provided accurate frequency measurements on different molecular transitions in the lower part of the THz spectrum (<4 THz), the only continuous-wave (CW) sources spanning the whole Terahertz window dates back to the mid 80s years, being represented by the Tunable Far-Infrared Lasers (TuFir) approach based on difference frequency generation (DFG). However, the low reliability and very low emitted powers of that very bulky instrumentation, hampered for decades its widespread use.

On the other hand, the tremendous progresses meanwhile achieved in the optical telecommunication field, have made available plenty of nonlinear integrated optical devices, as well as robust, compact and powerful infrared laser sources. This has created the conditions to imagine a novel family of DFG-based THz emitters, being able to compete with the precisions achieved by the most modern THz emitters and capable for spectroscopic measurement in the whole THz spectral window.

In this work we have realized a room-temperature CW THz spectrometer and its application to high precision spectroscopy in the 1-7.5 THz range.

The followed experimental strategy, based on difference frequency generation in a lithium niobate waveguide, allowed us to transfer to the THz frequencies the spectral purity and the tunability which characterize of the most mature technologies in the infrared part of the electromagnetic spectrum.

Furthermore, thanks to the surface emission geometry allowed by the non-collinear Cherenkov phase-matching scheme, the absorption losses, usually limiting the available THz power in the common nonlinear generation setups, have been minimized enough to allow both room-temperature detection and high-precision spectroscopy.