TeraHertz and metrology

The objective of this research activity is to develop optical means to generate frequency references with high spectral purity in the teraHertz range, with record frequency stability. The applications of such references are high-resolution teraHertz spectroscopy, teraHertz metrology, and heterodyn detection of THz signals at room temperature.

The scientific activities in this domain are closely related to the research carried out in **Laser dynamics**, and correspond to an extrapolation of our work in **Microwave photonics** to the teraHertz range.

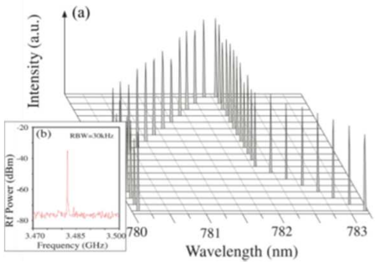
Opto-electronic phase lock loop

Very low phase noise microwave/THz signal generation on optical carrier at 1.5µm

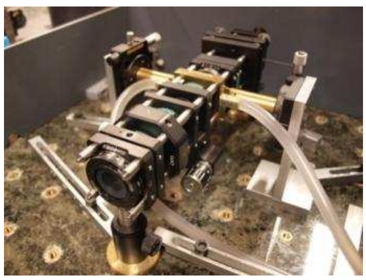
Design of a compact optical source of millimeter-wave radiation

Continuous THz source by photomixing at 800nm on Titane-Sapphire dual-frequency cavity

The realization of a continuous-wave THz source with photomixing technique requires producing a frequency beatnote with high spectral purity at a wavelength corresponding to available photomixers. The scheme of the dual-axis dual-frequency THz laser at 1.55 µm developed in the team and described above enables the production of a high spectral purity, tunable, microwave/THz beatnote. However, the best photomixers to date allowing generation of teraHertz radiation are made of AsGa-BT, and hence require a dual-frequency source whose optical carrier oscillates around 800 nm. The design of such a Titane-Sapphire laser source is currently being pursued in the team. Reaching single-frequency operation for each eigen polarization mode of the cavity is a mere challenge since the gain medium shows an extremely large spectral width of hundreds of nanometers. Therefore, standard filtering techniques used in commercial single-frequency Ti:Sa lasers cannot be used in a short-cavity dual-frequency laser [Loa14]. Within this framework, we have demonstrated the proof-of-concept of a Ti:Sa dual-frequency laser, with an optimized emission at 780 nm [Loa14], perfectly matching the spectrum of LT-GaAs photomixing devices. The THz beatnote is tunable over 2 THz (100 GHz steps), with a free-running linewidth below 30 kHz, which makes it a good candidate for the design of a high purity THz source. We currently apply laser stabilization techniques developped in the team to optimize the performance of the future sources in terms of spectral purity.



(a)



(b)

Fig. 7 : (a) Illustration of the spectral tunability of the two wavelengths of the dual-frequency dual-axis laser, producing a radiofrequency beatnote with narrow spectral width (30 kHz, see inset) ; (b) Photograph of the dual-frequency source.

Selected publications:

[Loa14] G. Loas, M. Romanelli and M. Alouini, "Dual-Frequency 780-nm Ti:Sa Laser for High Spectral Purity Tunable CW THz Generation," IEEE Photonics Technology Letters, 26 (15), 1518-1521 (2014).

Time-domain teraHertz spectroscopy

PhD theses (past / ongoing):

Antoine Rolland, « Oscillateurs ultrastables millimétrique et teraHertz par boucle à verrouillage de phase optoélectronique », 2013

Gwennaël Danion, « Oscillateur micro-onde à teraHertz ultra-stable », 2015

Joachim Boerner, « Theoretical and experimental study of ultrastable solid-state laser delivering millimeter wave and teraHertz signals »

Ayman Hallal, *« Laser impulsionnel à faible gigue »*

Collaboration:

Institut d'Electronique, de Microélectronique et Nanotechnologie – IEMN (Lille)

Laboratoire de Physique des Lasers, Atomes et Molécules – Phlam (Lille)

Thales Research and Technology (Palaiseau)

Observatoire de Nice-Côte d'Azur

Institut de Sciences Chimiques de Rennes

Resolution spectra systems

Menlo Systems

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