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

Identification of organic molecules emitted by living organisms could enable contolling the activity of bacteria, ground or fermentation processes, with numerous applications in food industry or biomedical diagnostic. Detecting the spectroscopic signatures of such molecules between 1 GHz and 1 THz (0.033 – 33.3 cm-1) requires the realization of tunable millimeter-wave sources in this frequency range. We have designed such a source by integrating optical components initially dedicated to optical communications (laser diodes, fibers,…). The optical source is capable of synthesizing waves between 1 and 500 GHz on an infrared optical carrier, with a 1 GHz tunability increment, while being more compact and versatile than existing optical or electronical realizations. This source has shown phase noise performances largely compatible with molecular spectroscopy at low pressure and ambient temperature [Hal16a, Hal16b].

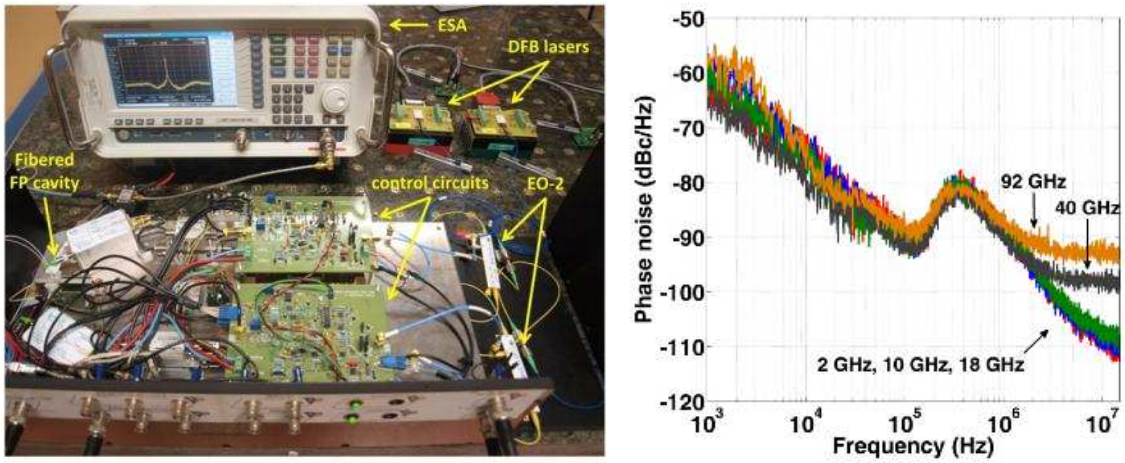

Fig. 6 : (a) Photograph of the source comprising two DFB lasers and the servo-control circuits ; (b) Phase noise of the millimetric beatnote at 2, 10, 18, 40 and 92 GHz.

Selected publications:

[Hal16a] A.Hallal, S. Bouhier, F. Bondu, "Synthesis of a 30 Hz linewidth wave tunable over 500 GHz", IEEE Trans. MTT 65, 1367-1371, (2016).

[Hal16b] François Bondu, Ayman Hallal, "Bruit des lasers dans la génération optique d'ondes submillimétriques pour la spectroscopie", Workshop Photonique et mesures de précision, Oct 2016, Paris, France.

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

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:

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

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Resolution spectra systems

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