# Microwave photonics

This scientific activity aims at generating and stabilizing microwave signals on optical carriers. High-stability frequency references generation in the microwave range can indeed lead to applications such as optical distribution of clocks or analogic signals for all-optical radar processing. In parallel, the theoretic and experimental study of microwave photonics links - as the one inserted in most recent radar architectures - is another field of research. Lastly, this research field aims at designing new architectures for highly tunable opto-electronic oscillators.

The studies conducted in this domain are closely related to other research fields investigated by the team, such as **Laser dynamics**, **TeraHertz and metrology**, but also to some of our developments in **Advanced imaging**.

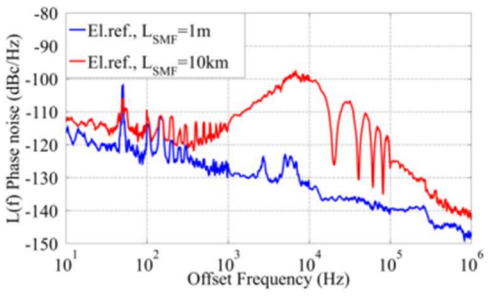
### Programmable optical generation of radiofrequency & microwave signals

### Microwave photonics links modeling

## Performances of microwave photonics links for analogic signals transmission

Like the design of low noise lasers, this research activity goes along with the growing role of optics in the core radar architectures, for distribution and/or processing of RF signals on optical carrier. Another application is the remote distribution of frequency references on optical links over long distances. What is at stakes with these studies is predicting the degradation of the performances of microwave photonics links (phase noise, distorsions, intermodulation products) in future conditions of use, and then finding solutions to overcome these problems. For instance, it is known that next generation radar architectures will be facing the effect of optical non linearities in fibers, due to the increase of the optical power and/or propagation distance [Pou13]. To carry out such investigations, the laboratory concentrates high-level equipments for microwave photonics, such as a 50 GHz Vectorial Network Analyzer, RF phase noise measurement benches, kilometric delay lines, dedicated optical amplifiers…

(a)




(b)

*Fig. 3: a) Photograph of a microwave photonics link and of the characterization equipments ; b) Degradation of the phase noise on a 10 km microwave photonics link due to optical non-linearities in the fiber.*

**Selected publications:**

[Pou13] L. Pouget, M. Alouini, A. Marceaux, T. Merlet, "Developement and optimization protocol of an additive phase noise measurement bench dedicated to long-haul microwave analog optical links," International Topical Meeting on Microwave Photonics (MWP), 2013, 202-205, (2013).

[Pou14] L. Pouget, A. Marceaux, T. Merlet, M. Alouini, "Optical nonlinearities in microwave photonic links: drawbacks and benefits," OPTRO Conference Proceedings, 2966221 (2014).

## Hybrid oscillators with opto-electronic feedback semi-conductors bi-lasers

## Optical control of antennas

## Optical amplification

**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*

*Lucien Pouget, « Contribution à l'augmentation des performances de liaisons optiques-hyperfréquences : non-linéarités et bruit »*

*Gael Kervella, « Circuits intégrés photoniques in InP pour la génération de signaux hyperfréquences », 2015*

Thong Tien Pham, *« Étude et conception d'antennes réseaux transmetteurs millimétriques à reconfiguration par voie optique »*

Aurélien Thorette, *«Structures de polarisation dans les lasers et réinjection : application à la génération de faisceaux opto-hyper »*

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