Spécialité de Master « Optique, Matière, Plasmas »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 22/10/2014

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Lieu du stage / *internship place*: Laboratoire Aimé Cotton, Orsay

Titre du stage / *internship title*: DUAL-FREQUENCY VECSELs FOR MICROWAVE PHOTONICS APPLICATIONS

Microwave photonics links will play an important role in future microwave systems. They allow for example to carry analog signals or radar local oscillators on an optical carrier over long distances. They also carry out a number of functions such as phase shifts, the introduction of delays on ultra-broad bandwidths, reconfigurable filtering of signals, or even more complex functions such as spectral analysis or correlation of microwave signals.

One of the key elements of such microwave photonics links is the laser source. In order for example to optically distribute a microwave local oscillator, one can use a single-frequency laser and modulate it with an external modulator. In this case, one needs a laser with an extremely low intensity noise [1]. An alternative strategy consists in forcing the laser to oscillate on two orthogonal polarization modes. The beatnote between these two modes then lies in the desired microwave range, and naturally exhibits a 100% modulation index. Moreover, the fact that these two frequencies originate from the same cavity allows them to exhibit a low noise. We have recently obtained such a dual-frequency oscillation from Vertical External Cavity Surface Emitting Lasers (VECSELs) [2,3], and deeply analyzed their noises and the amplitude and phase noise correlations between the two modes [4].

Another key element to future microwave photonics links is low noise optical amplifiers. However, conventional amplifiers, based for example on erbium-doped fibers, semiconductors, or Raman effect in fibers, degrade the signal-to-noise ratio. Indeed, quantum mechanics tells us that the noise figure of such phase independent amplifiers, that is to say that amplify similarly all quadratures of the field, cannot be less than 3 dB for a large gain. We have thus recently started to build so-called phase sensitive amplifiers based on parametric conversion in highly nonlinear fibers, and shown that such amplifiers are interesting for microwave photonics applications [5].

The aim of the present project is to associate these to developments and to amplify the optically carried RF signal generated by a dual-frequency using a phase sensitive amplifier. We will try to understand its classical and quantum noise behavior, and assess its linearity from the point of view of the carried RF signal.

This project is conducted in collaboration with Thales Research & Technology, the Laboratoire Kastler-Brossel, the Laboratoire de Photonique et Nanostructures, and the Physics Institute of Rennes

[1] G. Baili et al., "Shot-noise limited operation of a monomode high cavity finesse semiconductor laser for microwave photonics applications," Optics Letters 32, 650-652 (2007).
[2] G. Baili et al., "Experimental demonstration of a tunable dual-frequency semiconductor laser free of relaxation-oscillations," Optics Letters 34, 3421-3423 (2009).
[3] S. De et al., "Class-A dual-frequency VECSEL at telecom wavelength," Optics Letters 39, 5586-5589 (2014).
[4] S. De et al., "Intensity noise correlations in a two-frequency VECSEL," Optics Express 21, 2538-2550 (2013).
[5] T. Labidi et al., "Distortionless analog photonic link employing optical phase sensitive amplification," OSA Nonlinear Photonics Meeting, Poster JM5A.39 (Barcelona, 2014).

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : YES**

Si oui, financement de thèse envisagé/ *financial support for the PhD*: **DGA, EDOM**

Lasers, Optique, Matière	**X**	Lumière, Matière, Interactions	**X**
Plasmas : de l'espace au laboratoire			

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