PhD Thesis

Experimental and theoretical study of opto-microwave oscillators

Context

At IPR (Institut de Physique de Rennes), we generate optically-carried microwave signals by using the beating between the two modes of dual-frequency lasers. Such optically-carried microwave signals can take advantage of optical fiber technology to be conveniently transported over long distances, and are thus well adapted for applications such as radio-over-fibre, or optical transmission of radar signal . The lasers we use are either solid-state or semiconductor lasers. In particular, the latter are easily tunable, compact sources, well adapted for microwave photonics. We dispose of monolithic dual-frequency laser diodes developed by the 3-5 Lab, in the framework of an established cooperation. We have recently demonstrated their potential for microwave photonics, by stabilizing their beating on an external oscillator [1]. Our opto-RF oscillators raise also some fundamental questions. For instance, they allowed us isolating an a new synchronization regime: frequency locking without phase locking [2,3]. This regime, that has also been observed afterwards in hydrodynamical or mechanical systems, is still largely unexplored, together with its potential for the microwave photonics. Another open question is linked to delay. Indeed, the intrinsic time scale of semiconductor lasers is so short (< ns) that any optical feedback loop introduces a non-negligible time delay [6].

Objectives of the PhD

The PhD thesis aims at studying, experimentally and theoretically, new stabilization schemes based on opto-radiofrequency loops. In comparison to our recent work [1], the first step will consist in developing a stabilization scheme that does not need any external reference oscillator. This could be achieved by an optical and/or electronic feedback loop, with an adjustable delay, in order to self-stabilize the oscillator. Another possibility may involve a frequency-selective optical element. Different locking schemes will be realized and compared. Theoretical models will be developed in order to understand the role of the different parameters, and optimize the results. Given the complexity of delayed systems, these issues will be addressed first in solid-state lasers, easier to study than semiconductors [7].

Candidate profile

The candidate must have a master degree in physics, with solid bases in optoelectronics. Some notions of signal theory and modeling will also be appreciated. The subject is open and will be adapted to the profile of the student, who could focus more on experiments or on theory.

Funding

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Supervision, collaborations

The thesis will be done in the Institut de Physique de Rennes (https://ipr.univ-rennes1.fr/), under the supervisions of :

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This research will take place in the framework of an European project and of the CPER (Contrat de Plan Etat-Region). Concerning theory, the project will benefit from an established collaboration with the Theoretical Non Linear Optics group of the Université Libre de Bruxelles, directed by T. Erneux.

References

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