

interview

Yanne Chembo

“Proof of concept experiments have already proven that microwave photonic technologies can successfully compete with existing technologies.”



Dr Yanne Chembo leads a research group based at the FEMTO-ST Institute in France, affiliated with the French National Centre for Scientific Research (CNRS). In this interview he discusses his research and new paper, ‘Phase noise performance comparison between microwaves generated with Kerr optical frequency combs and optoelectronic oscillators’ page 264.

Can you give us an overview of your research?

My research group’s focus is on the exploration of nonlinear, quantum and stochastic phenomena in optoelectronics, microwave photonics, and laser physics. In particular, we investigate new architectures and systems at the interface between the microwave and photonic frequency ranges. A significant part of our research is devoted to the exploitation of the nonlinear and quantum phenomena hosted in ultra-high Q whispering gallery mode (WGM) resonators. We use these resonators to generate ultra-pure microwave signals, either through optoelectronic oscillators or optical frequency combs.

Could you explain what optical frequency combs and optoelectronic oscillators are?

Optical frequency combs are sets of equidistant lines in the spectral domain. They correspond to equidistant narrow optical pulses in the temporal domain. This technology gained major recognition in 2005 when John Hall and Theodor Hansch were awarded the Nobel Prize of physics for their pioneering contributions to this technology. Optoelectronic oscillators (OEOs) are based on a continuous, closed-loop conversion of energy from the electric to the optical domains. They are used in a wide variety of applications, including optical chaos cryptography and neuromorphic computing, our research group particularly investigates their performances for microwave generation.

What are the interesting applications of your field at the moment?

The main applications we are targeting are communication and aerospace engineering. In the microwave range, the desired output for applications is a low-phase noise signal, which can be used for radar or navigation purposes. In the optical domain, the optical frequency combs can be used for spectroscopy, or for coherent optical fibre communications.

The advantage of microwave photonics technology for these applications is that it allows us to benefit from: accurate control, acquisition and monitoring of signals in the electric domain; quasi-unlimited bandwidth, ultra-low losses and interference immunity in the optical range.

What have you reported in your *Electronics Letters* paper?

Kerr comb generators and optoelectronic oscillators are the two main competing microwave photonics architectures based on WGM resonators for microwave generation. We felt the need for a performance comparison between both systems in order to assess their advantages and disadvantages. We found that Kerr comb generators provide significant advantages with regards to WGM-based optoelectronic oscillators. Since they can output signals up to the 7th harmonic, they provide a higher microwave frequency versatility, while WGM-based OEOs are generally limited to the third. More importantly, Kerr comb generators are simpler and still able to output various types of combs.

What is the significance of your paper?

When various technologies are in competition, it is always useful to identify which one better fits a targeted application. In this work we find that Kerr combs outperform WGM-based OEOs, but other architectures of OEOs (e.g. fibre-based) provide phase noise performances that are unmatched to date. Because research is led by various groups worldwide to improve the performances of both types of oscillators, one should not consider these results definitive and universal.

How do you think your field will develop in the future?

Proof of concept experiments have already proven that these microwave photonic technologies can successfully compete with existing technologies. However, these oscillators are still laboratory systems, with a technological readiness level (TRL) of 3 or 4. Competing technologies, such as quartz for example, have reached the highest level of maturity and a maximum TRL of 9, with successful field deployment over more than 50 years. Therefore, the key challenge for microwave photonics technologies is to significantly increase their TRL in a relatively short term. Surprisingly the most difficult hurdles to overcome are related to engineering issues like packaging and norm constraints.

What is next for you and your research group?

Our interest on ultra-low noise microwave generation and metrology is still strong and will be for years to come. We are also interested in exploring quantum phenomena in WGM resonators, because once the so-called technical noise is reduced to its minimum, it becomes possible to observe genuinely quantum states with a large signal-to-noise ratio.