Chip-Scale Frequency Comb Sources for Teratronics and Terabit/s Communications

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Project description:

Optical frequency combs have revolutionized metrology and spectroscopy and may also become key components for high-bitrate optical data transmission and ultra-fast signal processing [1]. Frequency comb generation usually relies on mode-locked femtosecond lasers, which are often combined with highly nonlinear fibers for additional spectral broadening. However, despite the enormous potential, the technical complexity of current frequency comb sources is still prohibitive for many applications.

This project aims at realizing chip-scale frequency comb generators and at exploring their application potential in high-speed data transmission and ultra-fast optical waveform generation. Among other approaches, we envisage comb sources that exploit parametric frequency conversion in high-Q micro-resonators, so-called Kerr comb generation [2]. These devices can be built from low-loss silicon nitride (SiN) waveguides, thereby enabling co-integration of frequency comb generators with CMOS-compatible silicon photonic circuitry [3]. In previous experiments, we have shown that Kerr comb generators can be used as light sources for high-speed data transmission, even when phase-sensitive modulation formats such as 16-state quadrature amplitude modulation (16-QAM) are deployed [4]. However, in order to leverage the full potential of Kerr combs, further advances are needed with respect to device fabrication and stabilization of the comb generation process.

The project combines device-level research with system-level data transmission experiments: Novel high-Q microresonators with tailored spectral properties shall be fabricated using both in-house cleanroom facilities and cooperations with external technology partners. Moreover, the viability of these devices and of other frequency combs sources shall be demonstrated in Terabit/s data transmission experiments or in the context of optical arbitrary waveform generation. To tackle these challenges, we are looking for ambitious candidates holding a Master degree in electrical engineering, optics & photonics, physics, or related fields. Applicants should have profound theoretical background, basic experimental experience as well as good writing and oral communication skills. Candidates should further be able to work independently and self-motivated within an international team.

Work plan:

The work program comprises several steps:

- Investigation and evaluation of resonator designs for Kerr comb generation (KIT)
- Numerical modeling and design of frequency comb generator prototypes (ICFO/KIT)
- Fabrication of comb generators using facilities at KIT or cooperations with external partners (KIT)
- Characterization of fabricated comb sources and investigation of concepts for comb stabilization and synchronization (ICFO/KIT)
- Functional testing of various comb generators in Terabit/s data transmission (KIT)

References:

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[3] Levy, J. S.; Gondarenko, A.; Foster, M. A.; Turner-Foster, A. C.; Gaeta, A. L. & Lipson, M.: 'CMOS-compatible multiple-wavelength oscillator for on-chip optical interconnects', Nat Photon 4(1), 37—40 (2010).

[4] Pfeifle, J. *et al.*: 'Coherent data transmission with microresonator Kerr frequency combs', Preprint at http://arxiv.org/abs/1307.1037 (2013)