

Deliverable 4.1

Transferrable Skills Workshop 1

Computational Methods for Nonlinear Photonics at EPFL

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Abstract

Microresonator frequency comb generation lies at the intersection of fundamental physics, photonics and nonlinear dynamics. Its multidisciplinary nature requires innovative and specially-designed physical systems, and makes indispensable the ability to perform high-quality simulations of photonic systems and nonlinear dynamics, often with these properties interacting. This 2.5-day workshop provided fundamental understanding and practical know-how for performing simulations on photonic systems and nonlinear dynamics using different software tools, completed by hands-on exercises allowing participants to implement their own simulations guided by the topics presented. Overall, the participants gained valuable insight into various software and simulations as an indispensable tool for graduate students performing research in the field or seeking to transfer their skills to industry. Different topics were presented to include various interests in the field of photonics.

Introduction

The workshop “Computational Methods for Nonlinear Photonics (CMEP)” took place on 10 – 12 February 2020 at EPFL in Lausanne, Switzerland. All ESRs recruited thus far on the MICROCOMB ITN project attended, as well as other graduate students working in the groups of the consortium beneficiaries. A dinner for all participants and speakers was held on 11 February 2020.

The lectures were given by experienced postdocs and Ph.D. students from Prof. Kippenberg’s group at EPFL, the Laboratory of Photonics and Quantum Measurements (LPQM). Lectures covered a wide range of topics, from simple optical coupling and loss calculations to computation of the nonlinear dynamics of supercontinuum generation and dissipative Kerr soliton generation.

Lectures included case studies of actual systems, with the simulation process presented in a live, step-by-step manner – from understanding the physical model to final extraction of the relevant data. Simulations on integrated photonics focused on the finite-element method (FEM) using the ubiquitous COMSOL software, and finite-difference time-domain (FDTD) methods. Nonlinear dynamics simulations were presented using open-source packages established in the Photonics community in Python and Matlab.

Participants used their own laptops to follow the simulation steps.

A major emphasis was placed on hands-on experience with exercise sessions scheduled at the end of each day. Exercise sessions were particularly designed to combine skills and knowledge acquired by the participants during all the preceding lectures. Participants could implement their own simulations guided by the topics presented, and further understand both the simulation process and the underlying physics. The lecture sessions ended with a comprehensive overview of different experimental platforms and applications of nonlinear photonics.

Venue

Ecole Polytechnique Fédérale de Lausanne (EPFL) ; Lausanne, Switzerland

Workshop website:

<https://cmep-microcomb.epfl.ch/>

Topics

- General introduction and overview
- Introduction to COMSOL / Matlab LiveLink
- Dispersion engineering in optical cavities (axial symmetry) COMSOL
- Dispersion engineering in fibers and waveguides (COSMOL)
- Introduction to FDTD (Lumerical)
- Waveguide-resonator coupling (Lumerical)
- Fiber-to-chip coupling (Lumerical)
- Introduction to NLSE simulations / supercontinuum generation 1 (Matlab)
- Introduction to NLSE simulations / supercontinuum generation 2 (Matlab)

- Introduction to LLE simulations 1 (Python)
- Introduction to LLE simulations 2 (Python)
- Advanced aspects of LLE simulations (Pulse Driving /Soliton Molecules and Soliton Collision)
- Advanced aspects of LLE simulations (AMX/normal dispersion/Synthetic dimension)
- Applications of Nonlinear Photonics

YouTube channel

The lectures were audio recorded and are available on [LPQM's YouTube channel](#) dedicated to the CMEP workshop, as well as through the outreach section of the project website. It provides participants the opportunity to review the lectures and exercise sessions and use them as a base for performing their own simulations. Access to such online learning tools also provides exposure of the MICROCOMB training network to a wider community of graduate students and researchers.

Participants

- 13 MICROCOMB ESRs
- 5 non-ESR researchers from 2 beneficiary groups
- 9 speakers



Figure 1: Group photo of all participants and speakers



Figure 2: EPFL speakers Alexey Tikan (right) and Miles Anderson (left) in session