Thesis / Internship:
Optic-Electronic-Optic Interferometers for Advanced Coherent Optical Signal Processing

Interferometers are key components in many optical systems, including optical communications, precision metrology, and sensing. In conventional interferometers, an optical signal is split, processed through fixed optical paths, and recombined to produce interference. While effective, such systems offer limited flexibility, as the signal processing is constrained to the optical domain.(Fig. 1(a)). In contrast, an optic-electronic-optic (OEO) interferometer converts the optical signal into the electrical domain via coherent detection, enabling advanced and reconfigurable digital signal processing (DSP) before remodulation and optical recombination. This hybrid architecture greatly enhances system flexibility while preserving coherent interference (Fig. 1(b)).

Previous work has demonstrated coherent add–drop multiplexing in dense WDM systems using QPSK modulation. In this project, the system will be extended to higher-order modulation formats (e.g., 16-QAM), and the impact of finite local oscillator (LO) laser linewidth (e.g., ~100 kHz) on coherence and interference contrast will be systematically studied. Further extensions may include spectrally overlapping subcarriers and the implementation of a full coherent DSP chain, including timing and carrier recovery, with a focus on real-time FPGA-based processing.

Tasks may include:

- Develop and simulate DSP algorithms using MATLAB/Python.
- Implement selected DSP blocks in VHDL, focusing on fixed-point and real-time operation.
- Design and optimize control and synchronization algorithms.
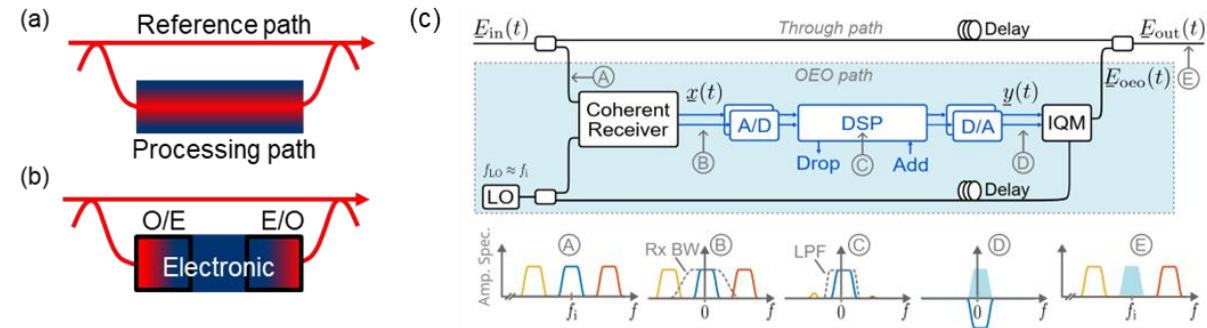- Experimental evaluation of system performance.

Fig. 1. (a) Conventional interferometer with an optical processing path. (b) OEO interferometer with opto-electronic and subsequent electro-optic conversion. (c) Basic building blocks of an OEO interferometer.

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Reference: Mahmud, *et. al.*, Optic-electronic-optic interferometer enabling coherent optical add-drop multiplexing," Opt. Express 33, (2025).