Soutenance de thèse

Vendredi 21 mars 2025
10h00 - Amphithéâtre

High-fidelity photonic quantum information : protocols and universal circuit control

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Jury members

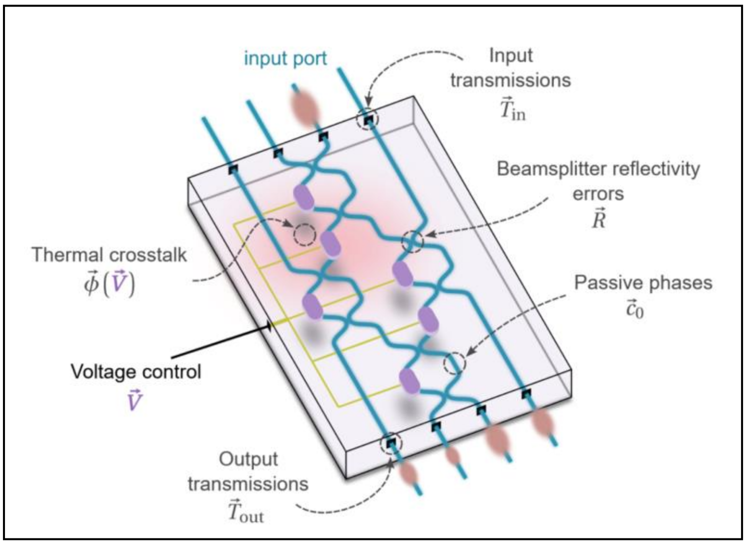
Pr. Stefanie Barz (University of Stuttgart)
Pr. Val Zwiller (KTH Royal Institute of Technology)
Pr. Rachel Grange (ETH Zurich)
Pr. Alberto Peruzzo (Qubit-Pharmaceuticals)
Pr. Benoit Valiron (Université Paris-Saclay)

Invited members of the jury

Nadia Belabas (Thesis director – C2N)
Nicolas Maring (Quandela)

Abstract

In this PhD thesis, we advance integrated photonics for quantum information processing by improving the calibration and control of photonic integrated circuits (PICs). PICs enable compact and stable light manipulation for a wide range of applications in optics. We demonstrate quantum protocols on specialized PICs, including the first on-chip certified randomness generation and high-fidelity 4-GHZ state tomography. In universal PIC architectures, we develop a machine learning-assisted characterization technique to mitigate hardware imperfections, achieving a record 99.77% fidelity in unitary operations on a 12-mode interferometer. Finally, we refine crosstalk models and propose a robustness criterion for interferometer design, enhancing PIC control accuracy. Our results, including a patented machine learning-based method, contribute to both quantum and classical integrated photonics, advancing scalable photonic quantum computing.



Photonic integrated circuits (PICs) consist of waveguides (blue lines) guiding light across a slab of transparent material. PICs often exhibit various imperfections resulting from fabrication constraints, tolerances, and operation wavelength, illustrated here on a simplified PIC. In general, input and output ports have different optical transmissions. In addition, the actual beamsplitter reflectivity values deviate from the target. Phase shifters (purple components) dissipating heat entail that all the implemented physical phase shifts depend on all the applied voltages. Finally, optical path variations lead to non-zero phase shifts even without any voltages applied. We use machine-learning to find suitable values for each of these parameters.