<Professor Youngik Sohn's Lab.>

Quantum Device Lab

■ **Contact information**
Professor : Youngik Sohn (youngik.sohn@kaist.ac.kr)
Website : https://qdlab.kaist.ac.kr/

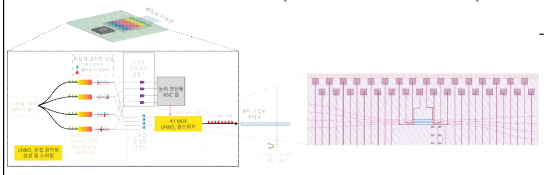
■ **Current state of the Lab. (in 2025 Spring Semester)**

Postdoctoral Fellows : 1 PhD Students: 7 Master's Student: 4

■ **Research Areas**

- Application of Feed-forward: Determinisitic Single photon source

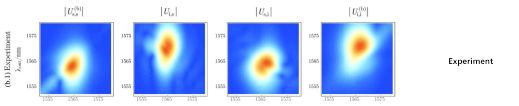
In Linear Optical Quantum Computing (LOQC), single photon sources are typically realized using pair-generation techniques such as SPDC or SFWM. These techniques rely on inherently probabilistic nonlinear optical processes. It's worth noting that the generation of the signal photon and idler photon is consistently pairwise, implying that the presence of a signal photon can be heralded through the detection of its corresponding idler photon.
However, the inherent probability of achieving pair-generation is fundamentally limited, with an upper bound of 1/4. As a consequence, feedforward-controlled multiplexing, which breaks upper bound of generation rate, becomes an essential component in these systems.
Multiplexor is basically an optical switch controlled with RF input. The probability of generation of multiplexed photon source is $P_0 = 1-(1-P_{pair})^n$. In the case of $P_{pair} = 1/4$ and n =16, total output probability $P_o \approx 0.99$.



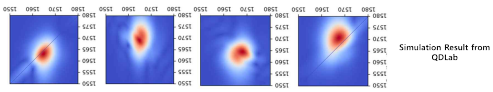
- *Multiplexing implementation : GMZI*
The multiplexing functionality was realized using the Generalized Mach-Zehnder Interferometer (GMZI). For a multiplexer with n inputs, only n active components of the GMZI are required for effective implementation.

- Nonlinear Quantum Photonics simulation

Producing a single photon source necessitates the utilization of photon pair generation through the parametric process, a manifestation of nonlinear quantum mechanics. For these process to be effective in diverse applications—such as quantum computing, quantum frequency conversion (QFC), and quantum communications—precise engineering of the photon pair generation process is imperative. A fundamental step in this engineering process is simulating the photon pair generation.



(Triginer et al. "Understanding High-Gain Twin-Beam Sources Using Cascaded Stimulated Emission", Phys. Rev. X (2020))



(Kim et al. "Simulation of integrated nonlinear quantum optics: from nonlinear interferometer to temporal walk-off compensator", in arXiv (2024))

We've developed a Python-based simulator capable of analyzing the nonlinear quantum processes involved in photon generation. It can model changes in laser spectrum, energy, waveguide geometry, and poling domain configurations. Unlike traditional methods relying on perturbation approximations, our tool offers exact solutions across both low and high pump gain regimes. The simulator's accuracy has been validated against actual experimental results.

■ **Recommended courses & Career after graduation**

- Electromagnetics, Quantum Optics, Quantum Computing, Optical Electronics, Nano-photonics
- You`ll earn various knowledge from theory to experiment in Quantum field. Based on your will, Youngik will support everything for you to get publications and become a leading researcher in this field from industry to academia.

■ **Introduction to other activities besides research**

Beyond research, we enjoy various outside-lab activities such as hiking and picnic, sometimes we do sports together like table tennis.

■ **Introduction to the Lab.**

We are hiring students interested in exploring the world of quantum!
Please contact Prof.Sohn to learn anything about quantum computing research. All inquiries are welcome.

■ **Recent research achievements ('23~'25)**

- Simulation of integrated nonlinear quantum optics: from nonlinear interferometer to temporal walk-off compensator(Seonghun Kim, Youngbin Kim et al, Physical Review Applied 22 (6), 064092)
- High-gain photon pair generation in a microring resonator with time-dependent non-perturbative effects (Youngbin Kim, Seongjin Jeon et al, Physical Review Applied 23 (5), 054045)
- Ultra-fast and accurate multimode waveguide design based on dataset-based eigenmode expansion method(Jaesung Song et al, in arXiv)
- Rapid adiabatic couplers with arbitrary split ratios for broadband DWDM interleaver applicatio (Daehan Choi, Woo-Joo Kim et al, in arXiv)