Improving the performance of linear transformations on a photonic chip.

1. **Company information:**

The mission of QuiX Quantum BV is to deliver quantum technology solutions based on silicon nitride photonic integrated circuits. QuiX Quantum BV is a new start up founded in January 2019 as a spin-off of the university of Twente. The flagship product of QuiX Quantum BV is a programmable photonic processor, which can be used to perform arbitrary linear optical transformations. Our targeted markets are the academic community and early adopters. QuiX Quantum BV has delivered a first generation of photonic processor and is currently developing a second.

2. **Problem:**

Quantum computing has the potential to revolutionize the way in which we process information. At QuiX Quantum BV, we pursue quantum computing using photons as information carries. A photonic quantum system consists of three parts: a series of photon sources which provide the quantum particles, a large, controlled linear optical system in which these photons interfere, and a series of detectors which read out the result of the computation.

QuiX photonic processor

The key challenge is to make all of these parts as large as possible, since this increases the overall computational power. QuiX Quantum BV focusses on the second part of this system: **the interferometer**. We deliver the capability to accurately manipulate large numbers of optical modes simultaneously.

Our product (shown above) achieves this by integrating the required hardware onto a photonic chip. The chip exploits the fact that any multimode optical transformation can be decomposed into a series of nearest-neighbour interactions to achieve all-to-all coupling while keeping a planar structure. We can adjust these interactions via control elements, and the specific layout of the chip guarantees that any transformation can be implemented.

QuiX Quantum BV wishes to scale up this system from 12 optical modes to 50. However, for this, the **degree of control is a problem** since the number of nearest-neighbour interactions happening at each mode scales linearly with the number of modes. Thus, increasing the number of optical modes means that a fixed error at each interaction translates into a much larger error in the overall system. Therefore, we pose the following question:

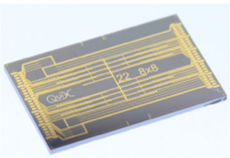
How can we decrease the level of errors when programming out an optical transformation in a photonic processor?

This scientifically challenging problem is amenable to solutions from several directions. The PwI team could take a high-level approach and find a better way of programming the existing layout of nearest-neighbour interactions, or one could develop a novel layout. Another approach could be to use redundancy in the optical elements to rectify mistakes which occur on one point of the chip in another point.

We believe it is possible **to obtain a solution in a week.** We will provide participants which a high-level description of our optical chip that they can directly use to test their ideas for new chip layouts. We anticipate that waveguide design will not be part of the approach taken due to the specialist background knowledge required. Rather, we will focus on the placement of existing components on chip.

The QuiX Quantum photonic processor allows for many applications which could **benefit society** such as traffic routing, satellite positioning, pricing of derivatives, random number generation or calculate molecular spectra. Currently these applications are performed by classical computers, but since Moore’s law is reaching its end and the type of problems become larger and larger there is **urgent need** to find alternatives. The QuiX Quantum photonic processor enables two solutions to this problem. Using energy efficient photonic networks operating at the speed of light a significant increase in speed could be obtained when solving optimization problems classically. The second approach uses a non-classical light source as input for the QuiX Quantum photonic processor for quantum information processing applications.

Quantum computing was developed in the physics community and is currently being commercialized by more and more companies. To realize a useful photonic processor, it is important for us to get feedback an advice from **the physics community**. That is why the team at QuiX is looking forward to engage with the best of the dutch physics community. The problem is suited for both experimentalist and theorists preferable with knowledge of optics or integrated optics. Furthermore, almost all employees of QuiX Quantum BV have a background in academia, which makes it easy to connect and identify with the participants.



A photonic chip

Impact on QuiX Quantum BV for the workshop. The workshop will be a success for QuiX if strategies can be developed that improve the fidelity of the current photonic processor (working on 12 modes) from 95% to 99%. This will enable us to quickly scale up to a 50 x 50 photonic processor with high fidelity. If the findings of this workshop are successful, they could already be **implemented within 6 months**.