INTEGRATED QUANTUM PHOTONICS

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The first quantum revolution, occurred during the last turn of the century, established the underpinning principles of quantum mechanics. The semiconductor technology, based on transistors, diodes and assemblages of them, was born after the first quantum revolution, which can be then considered as the father of the microelectronics [1]. Since then, our understanding of the, somewhat weird, laws of quantum mechanics, such as quantum entanglement, superposition and wavefunction collapse, endlessly improved. We are now in the midst of the second quantum revolution, in which quantum technologies are starting to move from the laboratories to markets. Quantum technologies harness the unique law of quantum mechanics to beat what were thought to be the insurmountable limits of science and devices which are based on classical laws of mechanics and electromagnetism. Among these, silicon photonics integrated quantum circuits use photons as non-classical information carriers, and they have been demonstrated to be versatile devices capable of realizing a wide variety of tasks, such as quantum sensing, quantum computation and quantum simulation. This talk aim to provide a general overview of the subject, take stock of the state of the art and to show the future directions. Almost all of the building blocks of a complete integrated quantum circuit (simple sketch shown in Fig.1) will be presented, starting from probabilistic and quasi-deterministic photon sources to integrated single photon detectors based on superconducting nanowires. A circuit-approach to quantum computation, and the way it is possible to realize optical qubits using dual rail path encoding, will be presented as an example of application. I will try also to overview the current challenges, the perspectives and the future directions of the field.

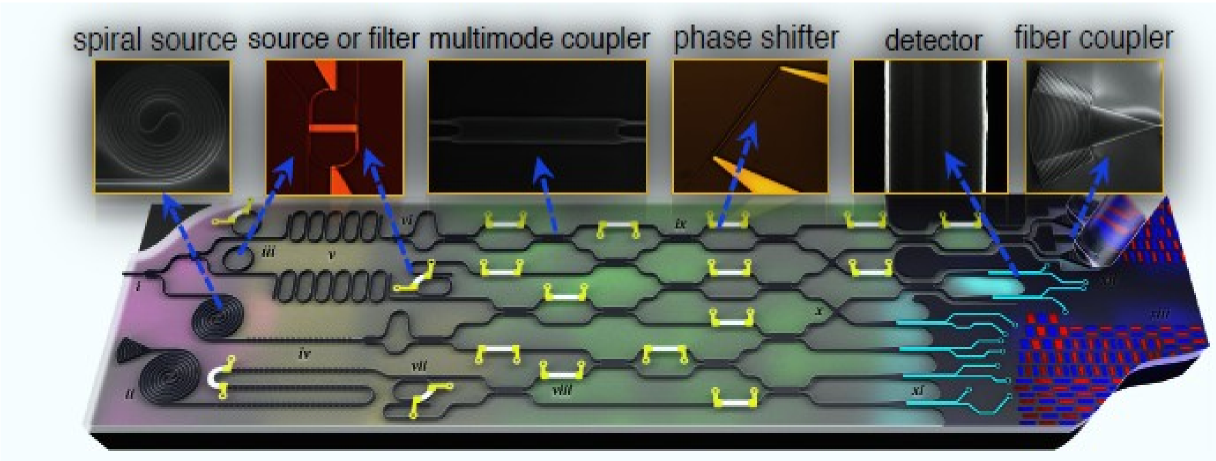

Fig.1. How a complete integrated quantum photonic circuit will probably looks like in the next few years (from [2]). From left to right: photon pairs produced by spiral waveguides will be filtered from the intense pump which generates them and subsequently coherently manipulated by a complex network of reconfigurable splitters and phase shifters. These optical qubits will be detected at the output of the circuit to form the result of the computation.

[1] J.P. Dowling et. al., *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences,* 361.1809 (2003)

[2] J. W. Silverstone et al., *IEEE Journal of Selected Topics in Quantum Electronics,* 22.6, (2016)