Quantum simulation with integrated photonics

Fabio Sciarrino

Dipartimento di Fisica, Sapienza Università di Roma,
Piazzale Aldo Moro, 5, I-00185 Roma, Italy
http://quantumoptics.phys.uniroma1.it
www.3dquest.eu

Integrated photonic circuits have a strong potential to perform quantum information processing [1, 2]. Indeed, the ability to manipulate quantums states of light by integrated devices may open new perspectives both for fundamental tests of quantum mechanics and for novel technological applications [3,4]. Within this framework we have developed a directional coupler, fabricated by femtosecond laser waveguide writing, acting as an integrated beam splitter able to support polarization-encoded qubits [5]. As following step we addressed the implementation of quantum walk. This represents one of the most promising resources for the simulation of physical quantum systems, and has also emerged as an alternative to the standard circuit model for quantum computing. Up to now the experimental implementations have been restricted to single particle quantum walk, while very recently the quantum walks of two identical photons have been reported. For the first time, we investigated how the particle statistics, either bosonic or fermionic, influences a two-particle discrete quantum walk [6]. Such experiment has been realized by adopting two-photon entangled states and integrated photonic circuits. As following step we have exploited this technology to simulate the evolution for disordered quantum systems observing how the particle statistics influences Anderson localization. Finally we will discuss the perspectives of optical quantum simulation: the implementation of the boson sampling to demonstrate the computational capability of quantum systems [7] and the development of integrated architecture with three-dimensional geometries [8,9].

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