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3d quantum integrated optical simulation

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Integrated photonic circuits have a strong potential to perform quantum information processing. 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. 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. As following step we addressed the implementation of quantum walk. For the first time, we investigated how the particle statistics, either bosonic or fermionic,influences a two-particle discrete quantum walk. As following step we have exploited this technology to simulate the evolution fordisordered 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 and the development of integrated architecture with three-dimensional geometries. We report the experimental observation of three-photon interference in an integrated three-port directional coupler realized by ultrafast laser writing. By exploiting the capability of this technique to produce three-dimensional structures, we realized and tested in the quantum regime a three-port beam splitter, namely a tritter, which allowed us to observe bosonic coalescence of three photons. Finally we implemented a small instance of the boson sampling problem by studying three-photon interference in a five-mode integrated interferometer, confirming the quantum-mechanical predictions. Scaled-up versions of this set-up are a promising way to demonstrate the computational advantage of quantum systems over classical computers. The possibility of implementing arbitrary linear-optical interferometers may also find applications in high-precision measurements and quantum communication.