Boson Sampling on a chip

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Integrated photonic circuits have a strong potential to perform quantum information processing [1, 2]. Indeed, the ability to manipulate quantum states of light by integrated devices may open new perspectives both for fundamental tests of quantum mechanics and for novel technological applications [3]. Boson sampling is a computational task hard for classical computers, but efficiently solvable via bosonic interference in a specialized quantum computer. We report several experiments of boson sampling implemented with integrated quantum photonics.

The evolution of bosons undergoing arbitrary linear unitary transformations quickly becomes hard to predict using classical computers as we increase the number of particles and modes. Photons propagating in a multiport interferometer naturally solve this so-called *boson sampling* problem, thereby motivating the development of technologies that enable precise control of multiphoton interference in large interferometers. We adopted, novel three-dimensional manufacturing techniques to achieve simultaneous control of all the parameters describing an arbitrary interferometer [4]. We implement a small instance of the boson sampling problem by studying three-photon interference in a 13-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 [4,5]. Furthermore we report a new variation of this task, *scattershot boson sampling*, which leads to an exponential increase in speed of the quantum device, using a larger number of photon sources based on parametric down-conversion [6]. This is achieved by having multiple heralded single photons being sent, shot by shot, into different random input ports of the interferometer. Finally we will discuss the development of integrated architecture with three-dimensional geometries [7,8,9].

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