Quantum optics: An entangled walk of photons

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Abstract

Although quantum effects such as entanglement and superposition are counterintuitive and often described as 'spooky', they are being observed and characterized in laboratories worldwide. The authors describe how they have designed and built an optical network, integrated in a glass chip, manipulates photons to simulate a process known as a discrete-time quantum walk. Furthermore, using a particular kind of entanglement, the authors simulated different classes of fundamental particles undergoing the quantum-walk process. The results are a step towards the development of quantum-mechanical machines that promise to outperform conventional supercomputers, which operate according to the laws of classical physics.
Developments in quantum simulation are still at the stage of mimicking systems simple enough to be handled with classical computers. However, photonics is an attractive candidate for reaching the point at which quantum machines could outperform state-of-the-art supercomputers for particular tasks. This is partly thanks to the complexity and stability of quantum networks realized with integrated optics, and to the nature of multiple identical photons interfering in a sufficiently complicated optical network.
However, a recent, and perhaps surprising, theoretical result is that a large number of identical photons themselves pose computationally difficult problems due to their bosonic nature, even in the absence of interaction. Using just tens of photons guided in a circuit with hundreds of waveguides could lead to the first quantum computation competitive with the equivalent calculation performed with the best classical computers currently available. Sansoni and colleagues' study is a development in this direction, and paves the way for using integrated quantum circuits to build a practical quantum simulator.

Reference:

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