CEWQO 2019

Quantum Walks with Non-classical Input States

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Abstract

We present an experimental platform enabling time-multiplexed photonic quantum walks with non-classical input states. It harnesses parametric down-conversion (PDC) states from an engineered source which are fed into a fibre-network where fast optical switches allow for a coin operation as well as controlled losses that are position-dependent. We report on the optimisation of the input modes' indistinguishability and experiments that probe this parameter. We discuss the suitability of the architecture for multi-photon experiments.

Quantum walks (QW) extend the concept of the classical random walk to the evolution of a quantum mechanical wave function. An experimental setup operating with coherent input states initialised in a single mode [1] already allows for the investigation of a wide range of phenomena, including percolation [2], topological effects [3, 4, 5] or measurement-induces effects [6]. However, a quantum system in the most general sense may involve multiple quantum particles in separated input modes.

In order to experimentally implement such a system, suitable in principle for linear optical computing or boson sampling, we advance the well-established time-multiplexing platform based on fibre loops to incorporate PDC input states (see Figure 1).

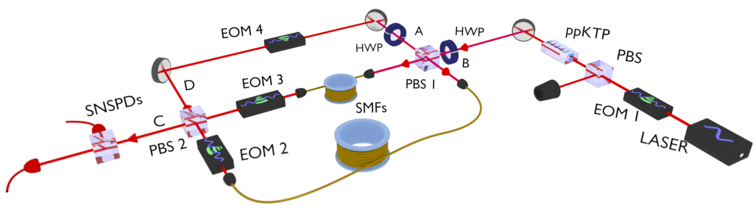

Figure 1: Sketch of the setup implemented for quantum walks with non-classical input states.

The visibility of the interference between input modes depends on their indistinguishability, which is sensitive to a wide range of experimental parameters. By conducting time-multiplexed HOM-interference experiments, we probe the parameter space and optimise along various dimensions: For example, we engineer the spectral characteristics of the source to approximate single-modeness in the Schmidt basis and minimise dispersion in the fibre loop, stabilise the temporal spacing of different modes and ensure homogeneous losses.

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