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A Single-Photon Source for Time-Multiplexed Quantum Walk

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Abstract

We report on the generation of single photon states optimal for time-multiplexed discrete-time quantum walk setup that employs a fiber network loop. This requires a photon source offering spatially and spectrally single mode state with high fiber-coupling efficiency, spectral purity, and brightness. We design a source based on type-II spontaneous parametric down-conversion (SPDC) in a periodically polled potassium titanyl phosphate (KTP) waveguide, pumped with picosecond pulses. We check the compatibility of the source for the desired quantum walk experiment by measuring overall detection efficiency after propagation trough the setup as well as Hong-Ou-Mandel visibility.

Quantum walks constitute a powerful model system for implementation of various physical phenomena ranging from simulating coherent energy transportation in biological systems to quantum computing. Among the existing experimental platforms, time-multiplexed coined quantum walk comes with distinct advantage of requiring limited resources as well as providing high control over coin and position states [1]. Time-multiplexing along with coherent input light has enabled demonstration of a host of quantum phenomena e.g. measurement induced effects [2], topological phases [3] and percolation [4]. The success of the aforementioned experiments is linked to the the well-established equivalence between the propagation of coherent light across a linear optical network and the dynamics of a single quantum particle. However, exploiting full quantum advantage of a quantum-walk system requires introduction of multiple indistinguishable particles, and thus one must consider incorporating single-photon sources. To this aim we design and implement a single-photon source suitable for our well-established time-multiplexed quantum walk setup. The source is based on type-II SPDC in a periodically

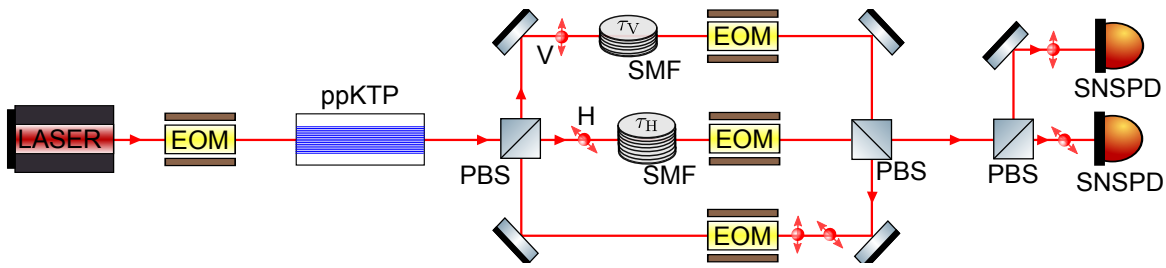

Figure 1: Schematic of the time-multiplexed quantum walk setup.

polled potassium titanyl phosphate (KTP) waveguide (AdvR Inc) that is pumped with narrowband (0.4 nm) pump laser. A proper choice of waveguide length (25 mm) ensures matching of the pump and the phasematching bandwidth and thus generates high spectral purity photons at telecom wavelength. Moreover, photons with narrow bandwidth (1.5 nm) minimizes the effect of dispersion in the fiber network. We finally check the compatibility to incorporate the source in the quantum walk setup for which we measure an overall efficiency after propagation through the setup along with the Hong-Ou-Mandel visibility.

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