Quantum information processing with multimode fiber

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The combination of a spatial light modulator (SLM) and a multimode fiber (MMF) can be used as a platform for programmable complex linear transformations in high dimensions. We show that two-photon quantum interferences can be controlled among different spatial and polarization modes in a deterministic way, thus demonstrating high-dimensional linear transformation across different degrees of freedom. We will discuss our current effort to implement interesting quantum circuit using such platform, for example, a unitary transformation for generating high-dimensional quantum states. We also demonstrate how such complex mixing allows measuring the purity and the dimensionality of the input quantum state, without measuring the density matrix *a priori*, simply exploiting the statistical distributions of classical speckle intensity and two-photon speckle pattern.

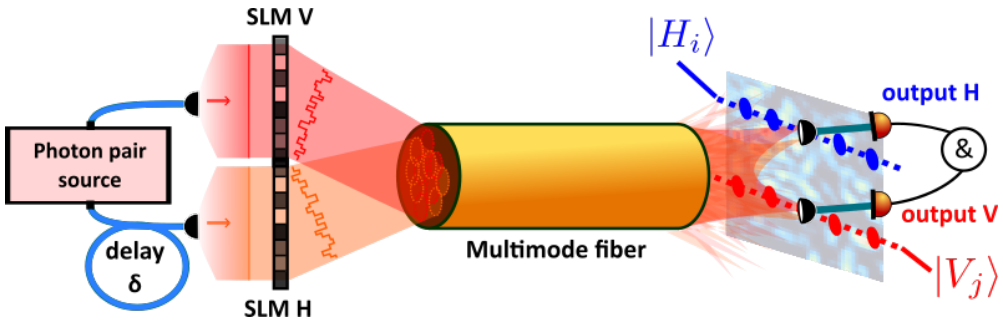

Figure 1: Programmable two-photon quantum walks through a multimode fiber (MMF): The transverse wavefronts of two-photon generated from a type-II collinear SPDC are independently modulated by the spatial light modulators (SLM V and SLM H). Different types of transformation can be implemented on the optical setup.