Quantum Simulations with Time-Multiplexed Photonic Quantum Walks

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Photonic quantum walk systems can be considered as a standard model to describe the dynamics of quantum particles in a discretized environment and serve as a simulator for complex quantum systems, which are not as readily accessible. However, their experimental realization requires setups with increasing complexity in terms of number of modes and control of the system parameters.

Here, we employ an optical feedback loop based on an unbalanced Mach-Zehnder interferometer, which provides high homogeneity, precise control of the system parameters and optimal resource efficiency [1–3]. In this time-multiplexing scheme the walker’s position is mapped into the time domain including the requisite interference effects. The realisation of dynamic sinks in the walker’s dynamics by applying a deterministic in- and outcoupling enables us to study measurement induced effects and recurrence probabilities [4].

When using a looped Michelson interferometer geometry instead, we are able to implement a 4D coin space for a 1D walk by exploiting the two different travelling directions in the loop in addition to the polarization of the walker. Fast electro-optic modulators realising dynamic coin operations enable us to study coupled quantum walks and finite walks with periodic boundary conditions.

References