Towards quantum simulation with cluster states using multi-photon interferences

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In a seminal paper in 2001, Raussendorf and Briegel [Phys. Rev. Lett. 86, 5188 (2001)] proposed a new scheme of quantum computing, the one-way quantum computer. Hereby, a large entangled state – the so-called cluster state – is created and the quantum computation is done via an adaptive sequence of consecutive single-qubit measurements. Cluster state quantum computing is universal and as such enables the execution of any quantum computation, in principle. Here, we propose how cluster states can be implemented in a probabilistic, fiber-based setup using single-photon emitters (SPE) and multi-photon interferences. In such a setup, the possible multi-photon quantum paths are designed and manipulated via different fibers lengths and half-wave plates such that cluster states are realized in the internal atomic or the photonic degrees of freedom upon coincident detection of the emitted photons. We indicate how these cluster states can be exploited for quantum simulation, e.g., of high-energy physics.

Figure 1: Ingredients to create cluster states via multi-photon interferences.