Experimental quantum fast hitting on hexagonal graphs

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Quantum walks are powerful kernels in quantum computing protocols, and possess strong capabilities in speeding up various simulation and optimization tasks. One feature of quantum walks on complex graphs that is key in quantum algorithms is their ability to propagate from a node to a distant one in an efficient way. This is often denoted as fast hitting. In particular, fast hitting on a structure known as glued tree is extremely charming due to its exponential speed-up over its classical counterpart. However, its experimental implementation is challenging, as this involves highly complex arrangements of an exponentially increasing number of nodes.

Here, we propose an alternative structure with a polynomially increasing number of nodes. We successfully map such graphs on quantum photonic chips using femtosecond-laser direct writing techniques in a geometrically scalable fashion. We experimentally demonstrate quantum fast hitting by implementing two-dimensional quantum walks on graphs with up to 160 nodes and a depth of eight layers. We demonstrate that the time for optimal hitting increases linearly with the layer depth, giving a quadratic speed-up over its classical counterparts. Our results open up a scalable path towards quantum speed-up in classically intractable complex problems [**?**].

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[1] H. Tang, C. Di Franco, et al., *Nature Photonics* **12**, 754 (2018).