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Fault-tolerant quantum computing with low component overhead

Quantum computers are inherently noisy, thus requiring error correction to mitigate noise. Unfortunately, the engineering overhead associated with error correction is currently massive, hindering the development of a large-scale fault-tolerant quantum computer. Current methods require hundreds if not thousands of experimental components to build a single error-corrected qubit that can run practical algorithms. Addressing this issue, Stanford researchers have proposed a simple protocol that minimizes the component overhead for fault-tolerant quantum computation. This approach is based on a novel procedure for fault-tolerantly preparing three-dimensional cluster states using a single emitter and a pair of delay lines (see figure below).

With continued improvements in only a few components, these systems can be promising candidates for demonstrating fault-tolerant quantum computation with a comparatively modest experimental effort.

Figure

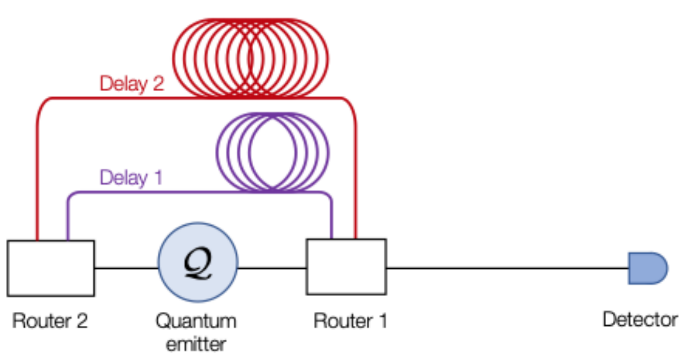

Figure description - A schematic illustration of the apparatus required to implement our protocol. Propagating modes, e.g., photons or phonons, interact with the emitter three times, followed by an adaptive measurement.

Stage of Development

- Early stage, experiment set-up completed

Applications

- **Quantum error correction**

Advantages

- **Advances the practical implementation of fault-tolerant quantum computing**
- Lower engineering overhead imposed by quantum error correction compared to current methods
- **Simple protocol** that minimizes the component overhead (from currently thousands to a few)
- **Incremental improvements** needed for only a few components

Publications

- Wan, Kianna, Soonwon Choi, Isaac H. Kim, Noah Shutty, and Patrick Hayden. "Fault-tolerant qubit from a constant number of components" *arXiv preprint arXiv:2011.08213* (2020)

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