Docket #: S20-399

Scalable Photonic Quantum Computer Design

Researchers at Stanford University have designed a scalable photonic quantum computer which does not require single-photon detectors and which uses minimal quantum resources: one coherently controlled atom. Photonics offers many advantages over superconducting systems as a platform for quantum computing, but it typically lacks scalability since machine size scales with quantum circuit depth. The Fan Group's design (Figure 1) uses a single atomic qubit controlled by a laser to indirectly manipulate the state of a large number of photonic qubits which counter-propagate through a fiber optic ring. Any quantum circuit can be deterministically implemented by this device, and readout of the quantum state is not limited by the low efficiencies of single-photon detectors. Unlike most designs for photonic quantum computers, the physical size of this device is independent of quantum circuit depth. This scheme has high fidelity even in the presence of realistic experimental imperfections and is significantly simpler and less resource-intensive than existing paradigms for photonic quantum computing.

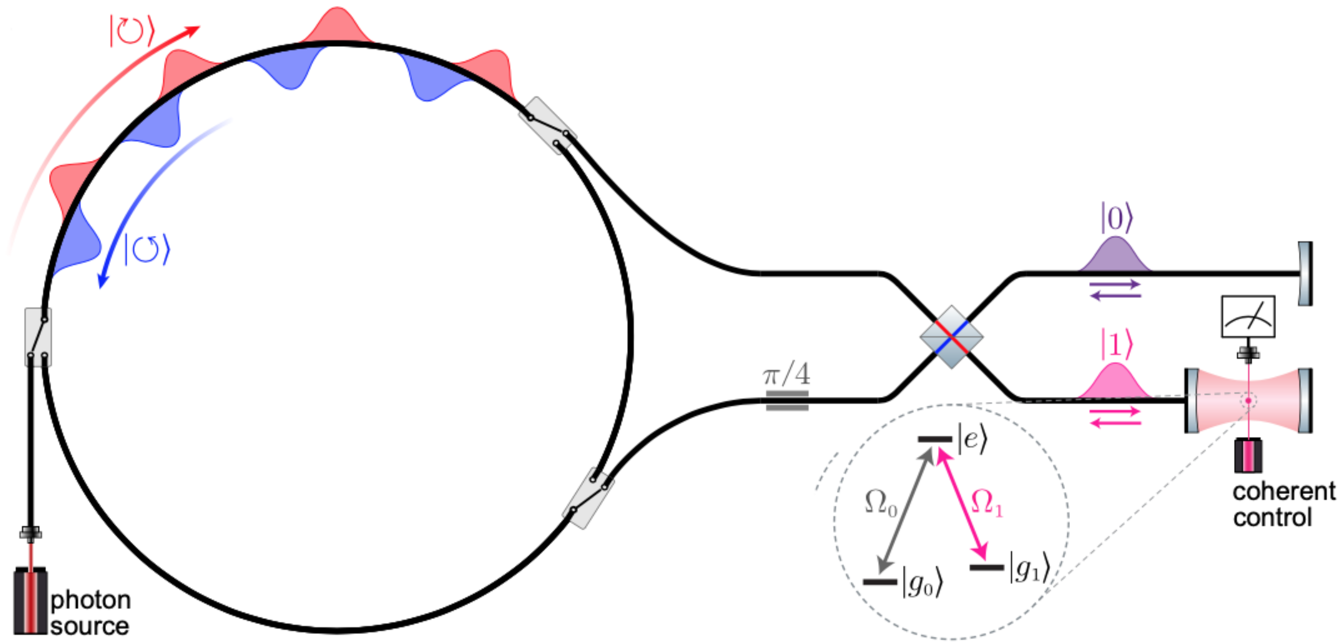

Figure 1. Architecture for a scalable photonic quantum computer Courtesy of The Fan Group

Stage of Development – Proof of Concept
The system concept has been proven theoretically and next steps are to build an apparatus.

Applications

- Quantum computing

Advantages

- **Scalable**: for a fixed number of qubits, the physical size of this design is independent of the depth of the circuit to be implemented
- **Experimentally simple**: only one controllable qubit is needed, bypassing the challenge of integrating many quantum gates or identical quantum emitters into a single device
- **Does not require single-photon detectors**, which are a significant limitation for photonic quantum computers

- **Deterministic**, and thus less resource intensive than cluster-state, measurement-based, or linear-optical quantum computing schemes

Publications

- Bartlett et al. arXiv (2020) "Deterministic photonic quantum computation in a synthetic time dimension"

Patents

- Published Application: WO2022076982
- Published Application: 20230376817

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