Networking Silicon Qubits

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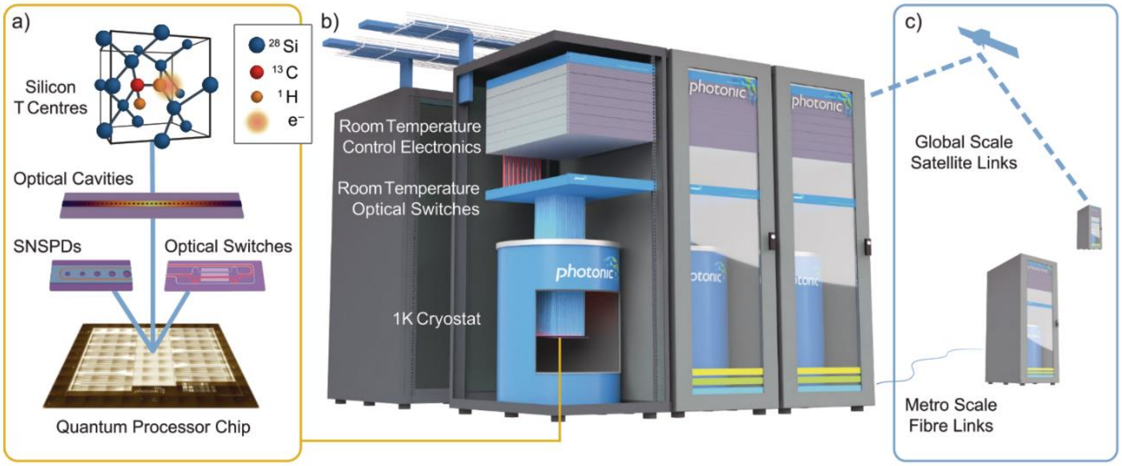

Fig.1. Photonic's networked quantum technology architecture, from Ref [6].

Quantum networking circumvents the size constraints facing quantum processors and delivers a path to fault-tolerant quantum computing at scale. Modular quantum supercomputers could solve commercially valuable problems requiring resources beyond forecast single-module capabilities. However, the quality and quantity of light-matter interconnects will be critical to the performance of networked quantum technologies. The silicon T centre offers optically-coupled spin processors as the basis for high-fidelity, high-speed distributed quantum computing. They combine direct telecommunications-band emission, long-coherence electron and nuclear spins [1], and proven integration into industry-standard, CMOS-compatible, silicon-on-insulator (SOI) photonic chips at scale [2,3].

In this talk I present recent advances characterizing and networking silicon T centre qubits. We determine the ground- and excited-state Hamiltonians governing both spin qubit coupling and optical emission frequency under applied magnetic, electric and strain fields [4]. We enhance the T centre optical emission rate by an order of magnitude with integrated silicon nanocavities to create coherent optical interfaces. We perform high-fidelity one- and two-qubit gates on-chip and demonstrate more than 200 ms of coherence time. We entangle two T centre devices in separate cryostats connected by optical fibre, establishing an inter-module link for distributed quantum computing and a quantum network node [5]. Isotopic variants of the T centre permit additional spin qubits at each device forming networked spin registers. Silicon T centre devices such as these are being directly integrated with on-chip photonic networks boasting low-loss active components, efficient coupling to standard telecommunications fibres, and efficient photon detectors. These elements combine to create networkable, scalable spin-photon quantum processors for fault-tolerant quantum computing at scale [6].

References

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