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【521】Quantum Information Science with Superconducting Circuits

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Superconducting circuits are a prime contender for realizing universal quantum computation in fault-tolerant processors and for solving noisy intermediate-scale quantum (NISQ) problems with non-error-corrected ones. Superconducting circuits also play an important role in state of the art quantum optics experiments and provide interfaces in hybrid systems when combined with semiconductor quantum dots, color centers or mechanical oscillators. In this talk, I will introduce the operation of superconducting circuits in the quantum regime and put quantum information processing with superconducting circuits into perspective with other solid state and atomic physics approaches. As one of two examples of our own research work in the area of fault tolerant quantum computing, which relies on the ability to detect and correct errors, I will present an experiment in which we stabilize the entanglement of a pair of superconducting qubits using parity detection and real-time feedback [1]. In quantum-error-correction codes, measuring multi-qubit parity operators projectively and subsequently conditioning operations on the observed error syndrome is quintessential. We perform experiments in a multiplexed device architecture [2], which enables fast, high-fidelity, single-shot qubit read-out [3], unconditional reset [4], and high fidelity single and two-qubit gates. As a second example, I will present the realization of a deterministic state transfer and entanglement generation protocol aimed at extending monolithic chip-based architectures for quantum information processing. Our all-microwave protocol exchanges time-symmetric itinerant single photons between individually packaged chips connected by transmission lines to achieve on demand state transfer and remote entanglement fidelities of about 80 % at rates of 50 kHz [5]. We believe that sharing information coherently between physically separated chips in a network of quantum computing modules is essential for realizing a viable extensible quantum information processing system.

[1] C. Kraglund Andersen et al., arXiv:1902.06946 (2019)
[2] T. Walter et al., Phys. Rev. Applied 7, 054020 (2017)
[3] P. Magnard et al., Phys. Rev. Lett. 121, 060502 (2018)
[4] J. Heinsoo et al., Phys. Rev. Applied 10, 034040 (2018)
[5] P. Kurpiers et al., Nature 558, 264-267 (2018)

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