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Superconducting Quantum-Classical Information Processing Systems

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Traditionally, the control and measurement of superconducting quantum devices including arrays of qubits are done using room-temperature classical electronics connected to cryogenic environment via high fidelity cables. This poses daunting technical challenges to quantum system scaling as the heat load, latency, noise associated with bringing signals in and out of the cryostat rise dramatically with number of quantum devices. By integrating the control and readout electronics into the cryostat in proximity to quantum devices, these problems can be drastically reduced to enable large-scale quantum arrays. This can finally lead to quantum processing systems that can outperform the best available classical supercomputers. Superconducting Single Flux Quantum (SFQ) digital logic can be a basis for the implementation of a proximal classical co-processor for low-overhead qubit control and measurement. SFQ digital circuits also can perform in situ classical processing of the results of quantum measurement to enable fast error tracking and feedback to stabilize the quantum array. Furthermore, hybrid quantum-classical systems integrating together the quantum and classical processing hardware units can match to various application algorithm architectures which typically combine quantum and classical algorithmic modules. Latest results in the SFQ-based digital control of superconducting qubits will be presented. The implementation of a scalable quantum-classical 3D integrated system extending across multiple temperature stages will be discussed.

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