**High-fidelity and robust quantum gates for superconducting qubits and semiconductor spin qubits**

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To realize practical quantum computation, the ability to precisely control qubit systems is a prerequisite. To increase the reliable circuit depth on noisy intermediate-scale quantum (NISQ) computing devices, or achieve the ultimate goal of error-corrected fault-tolerant quantum computation, constructing high-fidelity and robust quantum gates to meet the stringent computing requirements (beyond the fault-tolerant error threshold) is an important and timely issue. We apply the robust control method [1,2] to construct smooth optimal control pulses to enhance the gate fidelity and enlarge the robust window against noises and system parameter uncertainties for superconducting transmon qubits and semiconductor silicon-based quantum-dot electron spin qubits.

The two-qubit CZ gate infidelity of the directly-coupled superconducting transmon qubits with characterized noises of the fast dephasing contributed from the energy relaxation and from white noise potentially due to the room temperature control electronics (RTCE), and of the slow dephasing contributed from the flux noise (1/*f* noise) from the experiment [3] can be suppressed to , limited by the energy relaxation time . If is increased to [4], the infidelity can be further reduced to .

The two-qubit CNOT gate infidelity of the silicon-based quantum-dot spin qubits considering the dephasing noise and the control pulse uncertainty can still be suppressed to . The effect of the spin relaxation time in the spin-qubit system does not contribute appreciably to the gate infidelity as compared to the spin dephasing time since is usually two or three orders of magnitude larger than . We also demonstrate a high-fidelity (infidelity ) three-qubit Toffoli gate robust against the dephasing noise (the dominant error contribution due to the longer gate time of the Toffoli gate).

References:

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