Quantum logic with spin qubits crossing the surface code error threshold

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Abstract

High-fidelity control of quantum bits is paramount for the reliable execution of quantum algorithms and for achieving fault-tolerance, the ability to correct errors faster than they occur [1]. The central requirement for fault-tolerance is expressed in terms of an error threshold. Whereas the actual threshold depends on many details, a common target is the ~ 1% error threshold of the well-known surface code [2, 3]. Reaching two-qubit gate fidelities above 99% has been a long-standing major goal for semiconductor spin qubits. These qubits are well positioned for scaling as they can leverage advanced semiconductor technology [4, 5].

Here we report a spin-based quantum processor in silicon with single- and two-qubit gate fidelities all above 99.5%, extracted from gate set tomography [6]. The average single-qubit gate fidelities remain above 99% when including crosstalk and idling errors on the neighboring qubit. Utilizing this high-fidelity gate set, we execute the demanding task of calculating molecular ground state energies using a variational quantum eigensolver algorithm [7]. Now that the 99% barrier for the two-qubit gate fidelity has been surpassed, semiconductor qubits have gained credibility as a leading platform, not only for scaling but also for high-fidelity control.

References

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