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Rare-earth solid-state qubits

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Abstract

Quantum bits (qubits) are the basic building blocks of any quantum computer. Superconducting qubits have been created with a top-down approach that integrates superconducting devices into macroscopic electrical circuits, and electron-spin qubits have been demonstrated in quantum dots. The phase coherence time (τ 2) and the single qubit figure of merit (QM) of superconducting and electron-spin qubits are similar - at τ 2~ μs and Q M~10-1,000 below 100 mK - and it should be possible to scale up these systems, which is essential for the development of any useful quantum computer. Bottom-up approaches based on dilute ensembles of spins have achieved much larger values of τ2 (up to tens of milliseconds; refs 7,8), but these systems cannot be scaled up, although some proposals for qubits based on two-dimensional nanostructures should be scalable. Here we report that a new family of spin qubits based on rare-earth ions demonstrates values of τ2 (~ 50μs) and Q M(~1,400) at 2.5 K, which suggests that rare-earth qubits may, in principle, be suitable for scalable quantum information processing at 4He temperatures.

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