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Quantum Computation with Quantum Batteries

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The implementation of quantum logic in cryogenic quantum computers requires continuous energy supply from room-temperature control electronics. The dependence on external energy sources limits scalability due to control channel density and heat dissipation. Here, we suggest quantum batteries as an intrinsic energy source for quantum computation that facilitates quantum universal gate-set. We introduce a quantum battery that supplies energy for all unitary gates and enables all-to-all qubit connectivity. We find that the battery facilitates superextensive energy-transfer gates from the battery to the qubits and vice versa. The quantum battery plays an active role in the computation, enabling multi-qubit parity probing with a single entangling gate. We simulate a quantum error correction circuit with >98% fidelity in logical state encoding only through battery-qubit interactions. By eliminating the need for a drive line for each qubit, this architecture reduces energy consumption to readout-only and increases the number of qubits per cryogenic system by a factor of four. Quantum batteries thus offer a transformative paradigm for scalable and energy-efficient approach to next-generation quantum computation.

Theme

Theme 1. Energy advantage and cost of quantum technology

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