

Quantum Surgery Needs More Qubits Than We Thought

A new lower bound reveals a hidden cost in scalable quantum computing.

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$$\Omega(k^2)$$

Ancilla Qubits Required

For lattice surgery on sparse stabilizer codes, the overhead scales quadratically with code distance k .

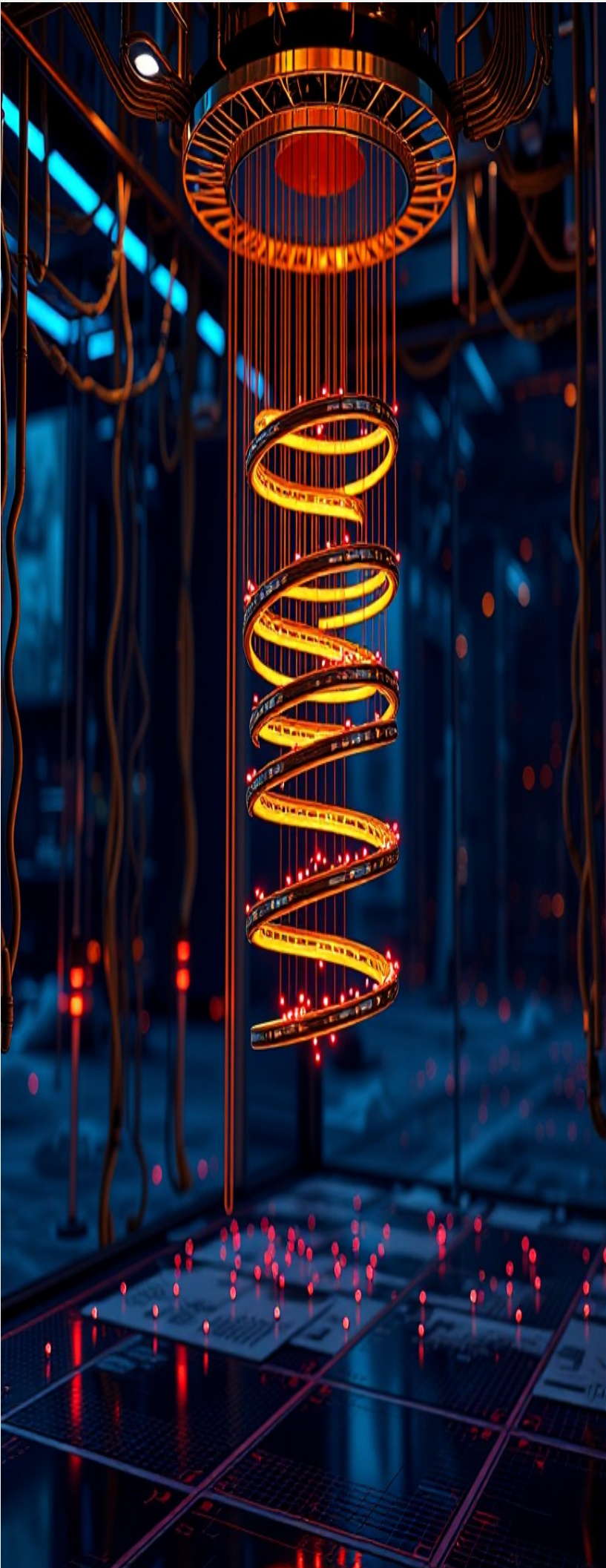
This result establishes that even with optimized ancilla design, the number of required qubits grows at least as k^2 in the worst case. For large- k codes—essential for fault tolerance—this implies that constant-overhead ancillas are insufficient for most measurement operations.



01

Scalability Has a Hard Mathematical Ceiling

The $\Omega(k^2)$ lower bound isn't just a practical hurdle—it's a fundamental constraint rooted in the algebraic structure of stabilizer codes. This means that no matter how advanced the hardware, scaling quantum error correction beyond moderate k will require exponential resource investment in ancillas, challenging the assumption of linear scalability in fault-tolerant architectures.



02

Surgery Is Not Just Efficient —It's Inherently Costly

Lattice surgery, often touted as a low-overhead method for quantum state manipulation, is shown to carry a non-negotiable resource cost. The result implies that the promise of modular, scalable quantum computation must be re-evaluated: the cost of inter-qubit operations may not be reducible below quadratic growth, which reshapes how we design fault-tolerant quantum circuits and allocate physical resources.

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