

QROM Costs Halved—Again

A new encoding method slashes quantum memory overhead with a twist on qubit bases.

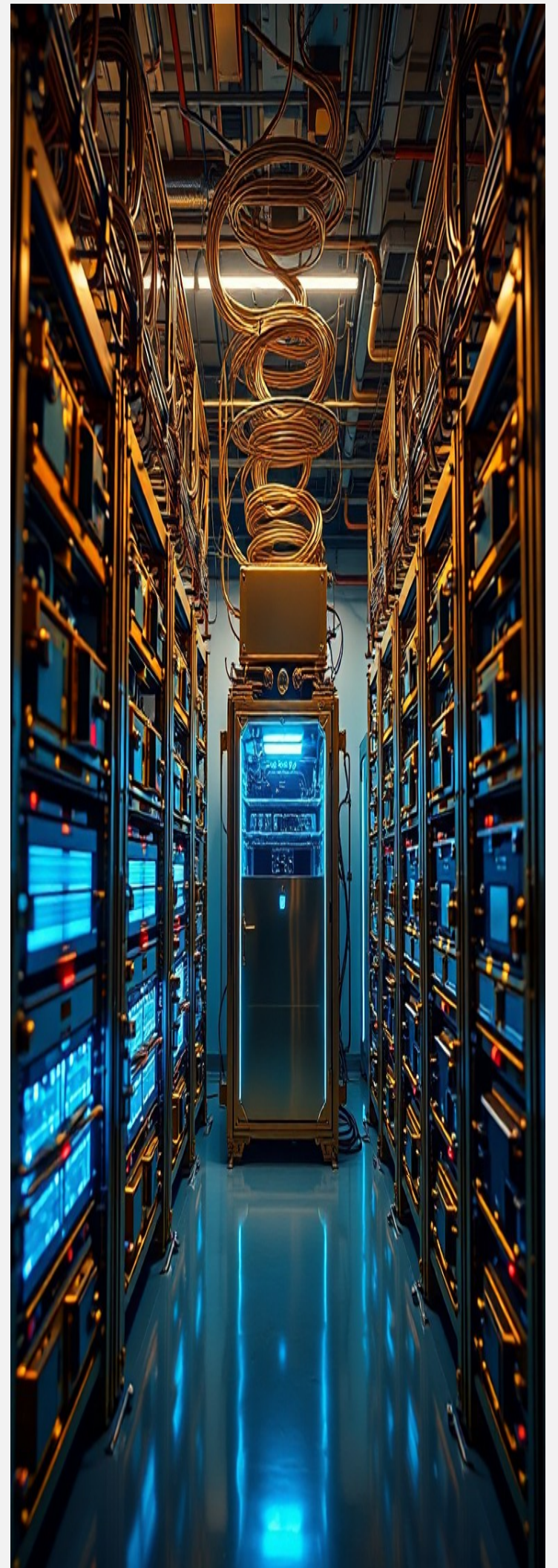
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$$\frac{1}{2}(1 + \frac{1}{b})N/\lambda$$

Leading Toffoli count in dense QROM

This formula represents the reduced gate complexity in the new dense encoding construction.

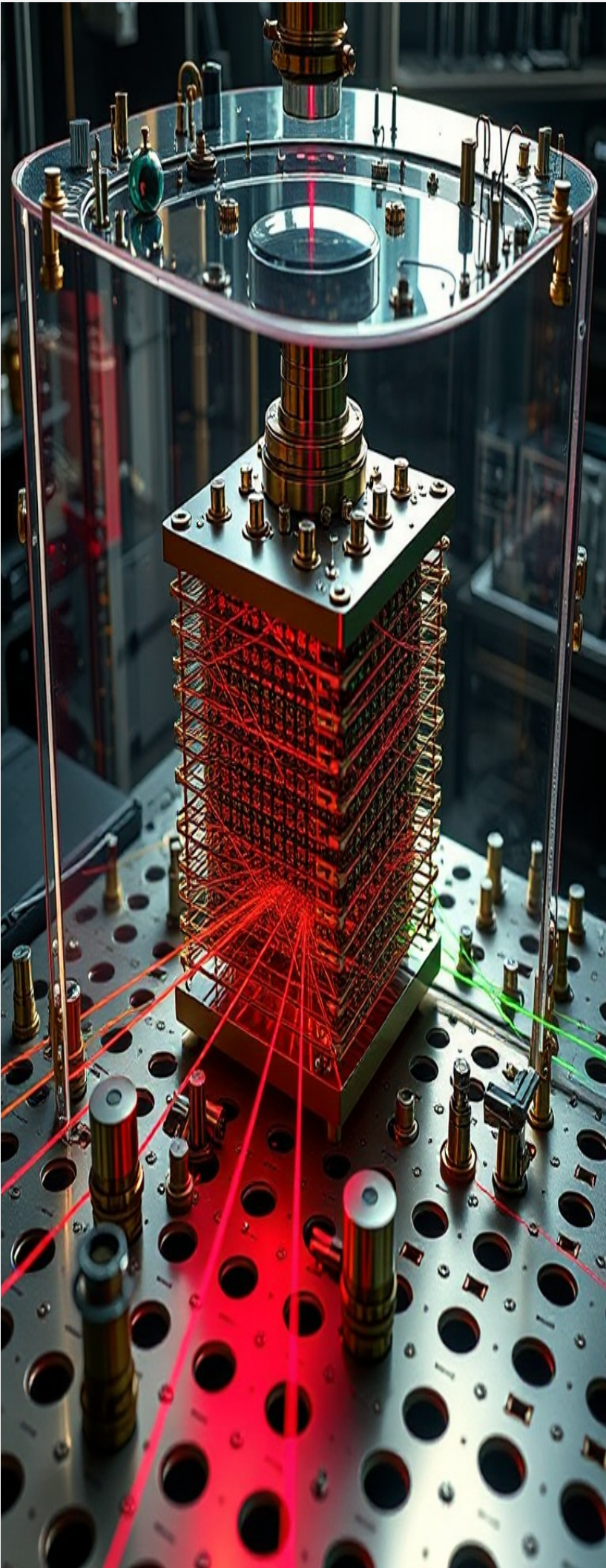
The new dense encoding construction achieves a halving of the leading Toffoli count compared to prior sequential bit packet methods. This improvement is not incremental—it's a fundamental shift in how classical data is embedded in quantum memory, leveraging both Z and X bases of dirty qubits to store two bits per qubit.



01

Base duality enables exponential efficiency

By utilizing both the Z and X bases of dirty qubits—typically reserved for computational or measurement states—this method effectively doubles information density without increasing physical qubit count. This is not just a coding trick; it's a redefinition of how classical data interacts with quantum hardware in constrained environments.



02

Fault-tolerant algorithms now scale cheaper

Since QROM is a major source of non-Clifford cost in fault-tolerant quantum algorithms, reducing its Toffoli count directly lowers the threshold for practical quantum advantage. The 4× improvement in the large-N limit suggests that memory-heavy algorithms—like quantum machine learning or simulation—may now be viable on near-term fault-tolerant systems with fewer resources.

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