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CURRENTSOTA

Physical qubits	1,180
2Q fidelity	99.99%
Logical qubits	96 LQ

Quantum hardware SOTA table →

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IBM与芝加哥大学实现超越经典模拟的验证逻辑量子计算

34 items · 10 sources | PDF |

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01 Highlights

Highlights

IBM and the University of Chicago jointly demonstrated verified logical quantum computation beyond classical simulation, achieving real-time error correction on logical qubits and executing random circuit sampling on a superconducting quantum processor for the first time, with results that cannot be

simulated by known classical algorithms[31]. This breakthrough marks the first time the superconducting approach has crossed the threshold of "logical qubits beyond classical," establishing a key milestone for fault-tolerant quantum computing[31]. IonQ completed its acquisition of SkyWater Technology, becoming a vertically integrated quantum platform company and internalizing fab capabilities, potentially accelerating the large-scale production of trapped-ion quantum computers[5][25].

02 Hardware

Hardware Frontiers

Superconducting Quantum Computing

IBM and the University of Chicago demonstrated verified logical quantum computation on a superconducting quantum processor, achieving real-time error correction and random circuit sampling on logical qubits, with computational complexity surpassing known classical simulation methods[31]. This is the first time the superconducting approach has reached "quantum supremacy"-level verification at the logical layer. Compared to Google's 2024 Willow surface code demonstration (surpassing classical at the physical qubit level, but logical qubits not reaching this milestone), this achievement surpasses classical capability under logical error correction protection, indicating that the error correction performance of superconducting qubits can now support computational advantage. Compared to the superconducting SOTA baseline, the error suppression factor Λ and logical qubit count for this result have not yet been disclosed; it remains to be seen whether subsequent data reaches or exceeds Willow's $\Lambda \approx 2.1$. Challenges such as TLS fluctuations, crosstalk during large-scale scaling, and cooling remain on the path to practical utility.

Trapped-Ion Quantum Computing

IonQ completed its acquisition of SkyWater Technology, becoming a vertically integrated quantum platform company with a U.S.-based

semiconductor fab[5][25]. This move means IonQ is internalizing the design, wafer fabrication, and packaging of trapped-ion quantum processors, helping to shorten R&D cycles, control the supply chain, and potentially accelerate its commercialization process. The current trapped-ion SOTA is held by Quantinuum (F_2Q 99.99%, 98 qubits all-to-all connectivity), while IonQ's F_2Q was around the 99.9% level before the acquisition; whether vertical integration can close the fidelity gap remains to be seen. The trapped-ion approach still faces bottlenecks such as qubit count scaling and ion transport overhead.

Photonic Quantum Computing

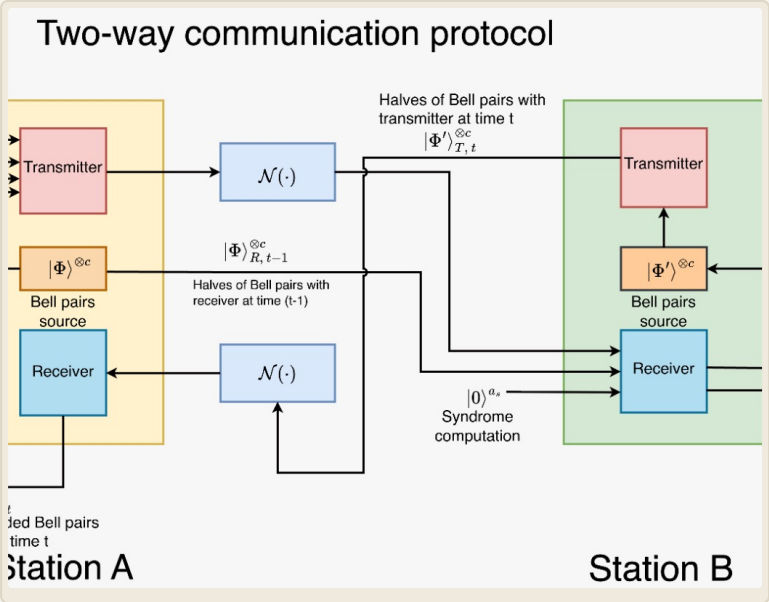
Researchers from Pusan National University and UNIST demonstrated direct two-photon interference between two different quantum light sources (a warm cesium atomic ensemble and a semiconductor quantum dot), achieving quantum interconnection between unsynchronized, independent sources[34]. This is the first time high-visibility interference has been achieved between such heterogeneous sources, providing a key interface technology for building scalable hybrid photonic quantum networks. Compared to the photonic hardware SOTA, PsiQuantum's independent source HOM indistinguishability has reached 99.50%. The specific interference visibility of this demonstration was not disclosed,

but the heterogeneous integration itself is a significant advance, broadening the material platforms for quantum photonics. Improving end-to-end loss budgets and overall fidelity remains necessary for practical utility.

Quantum Interconnects and Testing

QTREX's proprietary quantum interconnect platform exceeded the RF performance requirements set by partners in picosecond-level precision characterization[12]. Low-latency, high-precision interconnects are key to modular quantum computing architectures. This progress may provide a commercial-grade solution for communication between multiple quantum processors, but specific performance metrics (such as fidelity, loss) were not disclosed and await independent evaluation.

Algorithms and Software



Quantum Error-Correcting Codes

Researchers constructed several families of entanglement-assisted codes based on quasi-cyclic quantum low-density parity-check codes (EA-QC-QLDPC), implemented by tiling structured permutation matrices[16]. Entanglement-assisted QLDPC codes can achieve higher code rates or lower error thresholds for the same number of physical qubits. This method simplifies the encoding circuit through structured design, potentially reducing the complexity of experimental implementation and holding significant importance for realizing low-overhead quantum error correction.

Quantum Image Processing

A superpixel-based QUBO framework accelerated the quantum image segmentation problem by a

factor of 33[9]. This work combines image preprocessing with quantum optimization, demonstrating the acceleration potential of quantum algorithms in practical applications such as medical imaging, although the quantum speedup is against classical algorithms on a specific problem, and generality still needs verification.

Quantum Neural Networks

Researchers proved that complex Motzkin quantum states (special entangled states in one-dimensional quantum systems) can be exactly represented by neural networks[6]. Motzkin states possess complex properties such as volume-law entanglement. The neural network representation provides a new numerical tool for their application in quantum many-body physics and also aids in understanding the expressibility of quantum states.

Quantum Network Coding

A novel lossless source coding scheme achieved perfect fidelity on a 13-node quantum network using a prefix-suffix address space[11]. This scheme reduces communication overhead through a compact, hierarchical quantum address design, offering reference value for resource-efficient routing in large-scale quantum networks.

Industry and Ecosystem

Acquisitions and Integration

SEALSQ completed the deployment of a $200 million quantum fund, acquiring Miraex SA and initiating the commercial deployment of its quantum photonics technology[13][24]. Miraex focuses on quantum photonic integration. This acquisition extends SEALSQ from the semiconductor security sector into quantum communication and sensing, potentially accelerating the implementation of quantum-safe solutions.

Industry Forecasts

IBM's CEO expects quantum computing to begin generating revenue by the late 2020s and create a trillion dollars in value by the late 2030s[29]. This

forecast reflects the industry's optimistic expectations for the commercialization path of quantum computing, but it should be noted that quantum computing is still in its early stages, current revenue scale is minimal, and the trillion-dollar value depends on widespread application breakthroughs and ecosystem maturity.

National Strategies

France released its July 2026 National Quantum Update Report, outlining the current state of its quantum technology development[26]. France is a significant force in European quantum computing, home to startups like Pasqal and Quandela; this update provides reference for policy directions and funding allocations. The U.S. Naval Research Laboratory (NRL) announced the strategic research priorities of its Quantum Science Institute, focusing on quantum sensing, communication, and computing to support naval missions[33]. This reflects the defense sector's continued investment in military applications of quantum technology, potentially accelerating the practical use in specific areas (e.g., quantum navigation, secure communication).

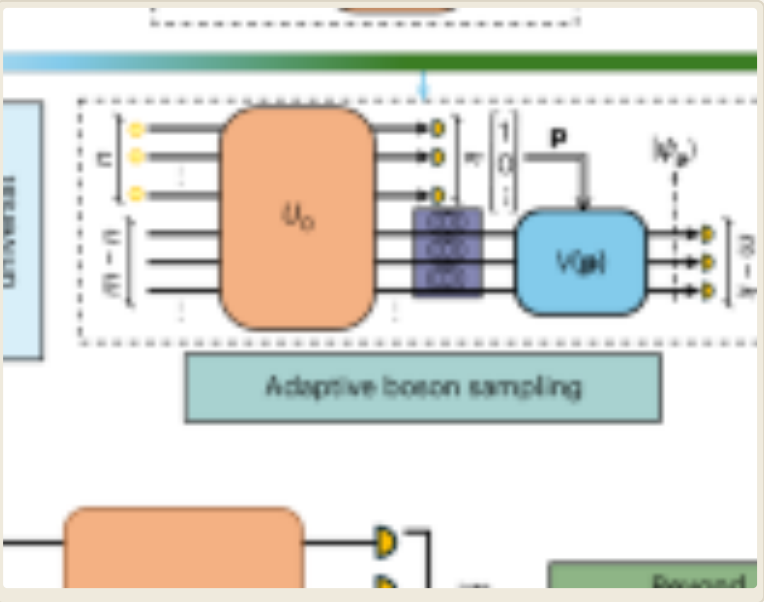
Post-Quantum Cryptography

A review article emphasized the importance of cryptographic agility for post-quantum cryptography migration[27]. With the release of

NIST post-quantum cryptography standards, enterprises need to design flexible cryptographic architectures to address future quantum threats, making cryptographic agility a key implementation principle.

05 Other

Academic Frontiers



Quantum Optics and Fundamental Physics

A theoretical paper proposed a scalable universal photonic quantum computing architecture, with the key being the introduction of strong nonlinear resources[4]. This architecture addresses the long-standing integrated nonlinearity bottleneck in photonic quantum computing; if experimentally realized, it would significantly enhance the feasibility of photonic quantum computers.

Stable Majorana characteristic current signals were observed in a quantum dot chain[14]. This system simulates "poor man's Majorana" modes on three quantum dots and verifies non-locality through current correlations, providing a more easily tunable platform for constructing topological qubits.

McKinstrie and Kozlov proposed a simplified path for calculating the Wigner angle[15]. The Wigner angle describes the rotation of quantum states under Lorentz transformations in relativistic quantum information. This method simplifies the calculation, aiding in handling entanglement behavior under complex transformations.

Quantum Information Theory

Research linking the Swampland conjectures to the freezing of quantum complexity indicates that Krylov complexity "freezes" in the extreme black hole limit, but Schwinger pair production can unfreeze it[8]. This work connects the Swampland conjectures in string theory with the concept of complexity in quantum information, offering a new perspective for quantum gravity research.

Quantum Simulation

Driving a resonant lattice generates controlled particle flow of a Bose-Einstein condensate in a double-well potential[10]. This research

demonstrates how to control quantum transport through driving asymmetry, providing guidance for quantum simulation and atom-optical devices.

Researchers at New York University Abu Dhabi developed a unified platform combining knot diagram construction with Chern-Simons invariant calculation, utilizing topological quantum field theory[7]. This platform provides an automated tool for anyon braiding and topological invariant calculations in topological quantum computing.

BlueQubit supported a study on error-mitigated quantum simulation by Qedma, IBM, and RIKEN[30]. Error mitigation is a key technique for achieving useful computation on current noisy quantum processors. This collaboration demonstrates a cross-platform error mitigation scheme, potentially improving the accuracy of quantum simulations.

06 Impact

This Week's Impact

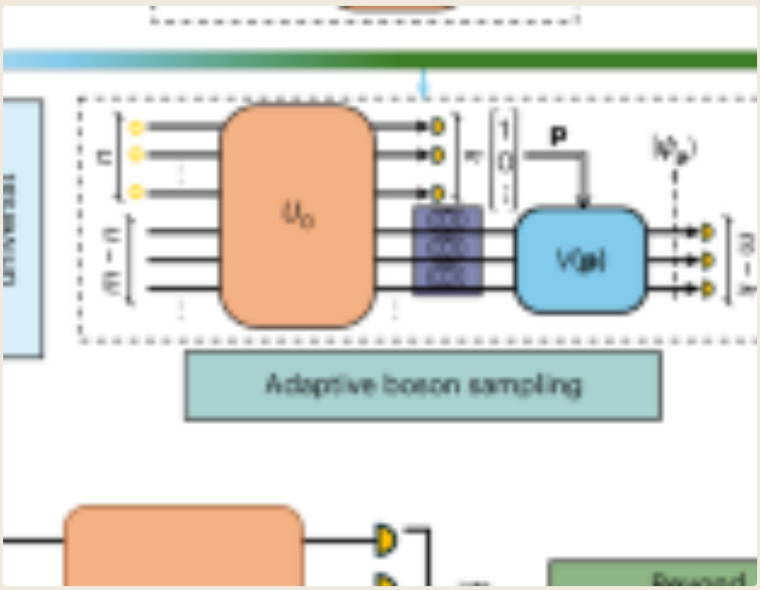
— **Superconducting Quantum Computing Researchers**: The logical quantum computation demonstration by IBM and the University of Chicago could alter the competitive landscape of the superconducting approach. Subsequent attention should focus on details of its logical error rate, code distance, and scalability, which will be key to judging whether the superconducting route can be the first to achieve practical fault-tolerant computation[31].

— **Trapped-Ion Quantum Computing Companies**: IonQ's acquisition of SkyWater marks a move towards vertical integration for the trapped-ion approach, potentially prompting other trapped-ion companies (like Quantinuum) to consider similar strategies to secure manufacturing capabilities and supply chain security[5][25].

- **Photonic Quantum Network Developers**: The success of two-photon interference between heterogeneous quantum light sources opens new possibilities for hybrid quantum networks. The next step is to monitor the scalability of this technology and its performance in real network environments[34].
- **Quantum Software and Algorithm Engineers**: The 33x speedup of the superpixel QUBO framework demonstrates the potential of quantum algorithms in image processing, but verification on larger-scale datasets and actual hardware is needed. Related fields can watch for its co-optimization with quantum hardware[9].
- **Post-Quantum Cryptography Migration Teams**: The emphasis on cryptographic agility reminds enterprises that PQC migration is not just algorithm replacement but also architectural design, requiring early planning to meet the rapid deployment demands after standards are finalized[27].

07 Other

Editor's Note



The most striking development in quantum computing this week is the breakthrough by IBM and the University of Chicago in verified logical quantum computation, marking the first time superconducting qubits have performed a computational task beyond classical simulation under error correction protection. This progress pushes "logical qubits" from error correction demonstrations to computational advantage verification, injecting a strong boost into the development of fault-tolerant quantum computers. However, we must remain level-headed: key metrics such as the number of logical qubits, error rates, and code distance have not been fully disclosed, and the large-scale scaling of the superconducting approach still faces engineering challenges like cooling, crosstalk, and material defects.

On the industry side, IonQ's vertical integration acquisition reflects the importance quantum computing companies place on supply chain control, potentially marking a turning point as the industry moves from R&D to manufacturing. Vertical integration helps accelerate iteration but also brings risks of capital intensity and reduced flexibility. Furthermore, progress in heterogeneous integration for photonic quantum computing and QTREX's interconnect platform testing indicate that modular and hybrid architectures are becoming mainstream trends. In the coming weeks, close attention should be paid to the detailed paper on IBM's logical quantum computation demonstration and the first product roadmap updates following IonQ's integration of SkyWater.

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[26] French National Quantum Update: July 2026

[27] Why Crypto-Agility Matters for Post-Quantum Cryptography Migration

[28] UC San Diego Advances Quantum Metamaterials for Ultrafast Optical Computing

[29] IBM CEO Expects Quantum Computing to Drive Revenue by 2020s, Trillion-Dollar Value by End of 2030s

[30] BlueQubit Supports Qedma, IBM and RIKEN Study on Error-Mitigated Quantum Simulation

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[32] Simantic scales from Waterloo startup to global AI hardware innovator

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