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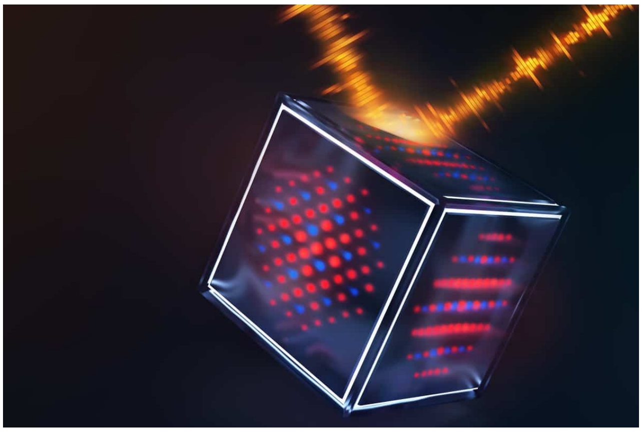
NTU Q

REAL-TIME ERROR CORRECTION EXTENDS THE LIFETIME OF QUANTUM INFORMATION



Credit: Volodymyr Sivak

A research team at Yale University has successfully observed and corrected errors in real time within a quantum system, allowing information to be preserved more than twice as long as previously possible. Quantum computing relies on specific physical systems, such as superconducting circuits, atoms, ions, or photons, to perform complex calculations. However, maintaining the delicate quantum states is challenging due to their susceptibility to noise.

Quantum information is typically stored as qubits, which can exist in a superposition of two different states simultaneously, like a photon with two polarization states. Error-correction methods require extra information to notify observers of errors and provide details for correction. These methods can utilize additional states in the same quantum system or combine multiple qubits.

Led by Michel Devoret, the team employed a qubit encoding called GKP code using light confined in an aluminum cavity connected to a sapphire chip with a superconducting qubit, or "transmon." To evaluate the improvement from error correction, the researchers compared the qubit's lifetime to the uncorrected lifetime of other potential qubits in the system. After error correction, the GKP qubit's extended lifetime was 1.82 ms, an improvement of 2.27 times.

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HITTING REWIND ON QUANTUM PROCESSES

In the observable world, physical processes appear to occur in a single time direction, such as eggs being scrambled but not unscrambled. However, in the quantum domain, processes can be reversed using rewinding protocols. David Trillo and his team at the Institute for Quantum Optics and Quantum Information in Vienna have demonstrated a protocol for two-level quantum systems with a guaranteed success rate, unlike previous approaches. This breakthrough opens the door for practical applications.

The new protocol operates by causing the target system to evolve along a quantum superposition of various paths. In some paths, the system progresses freely, while in others, it is subjected to an unknown quantum operation. The interference of these paths then forces the system to revert to its original state. Remarkably, this protocol necessitates no knowledge of the target system, its internal dynamics, or the applied operation. Additionally, the rewinding process is optimally efficient and can achieve an arbitrarily high probability of success.

Trillo and his team showcased their protocol using a complex optical setup, where they reversed the evolution of a two-level system represented by a photon with two potential polarization states. They emphasize, however, that their approach is not limited to photonic platforms. This guaranteed-success rewinding of a quantum system to a previous state could impact our comprehension of quantum mechanics and find applications in various areas of quantum information technology.

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