Doubling up Cooper pairs to protect qubits in quantum computers from noise

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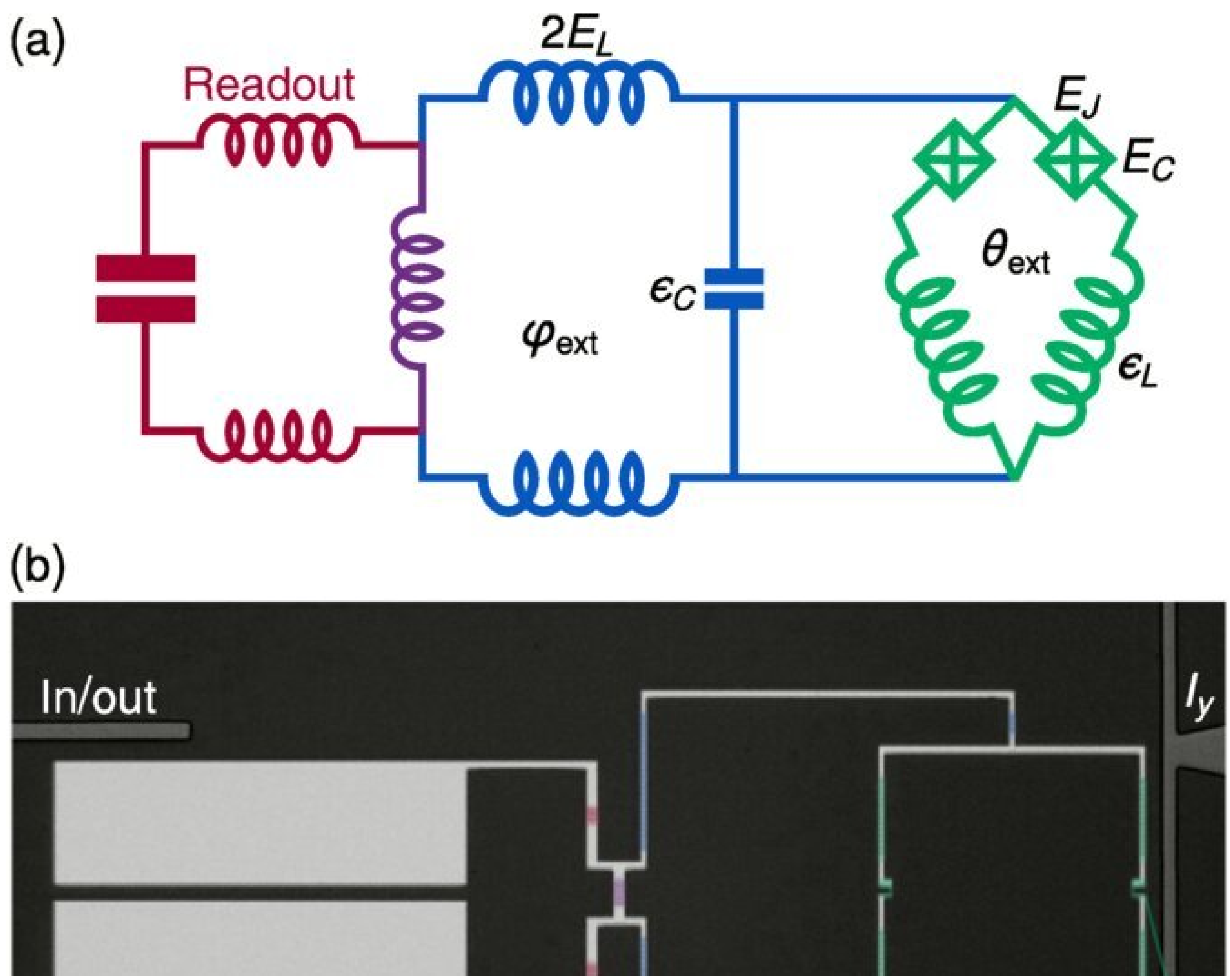

Experimental implementation. (a) Extended electrical circuit diagram for the inductively shunted KITE including the lumped LC oscillator (maroon) added for dispersive readout, which couples inductively to the circuit through a shared inductance (purple). (b) Optical micrograph of the physical device, with aluminum electrodes in light gray and niobium electrodes in dark gray. Direct currents, microwave drives, and readout signals are routed in and out of the system through two on-chip flux bias lines (right and bottom) and one weakly coupled pin (top left). Insets: scanning electron microscope images of one array of large junctions [all inductances pictured in (a) are implemented similarly] and one small junction. Credit: *Physical Review X* (2022). DOI: 10.1103/PhysRevX.12.021002

A team of researchers affiliated with several institutions in France has developed a means of using pairs of Cooper pairs to protect qubits inside a quantum computer from external noise. In their paper published in the journal *Physical Review X*, the group describes how they tackled the problem of qubit sensitivity to noise and how well their approach worked when tested.

An obstacle to the development of quantum computers is external noise affecting qubits. One of the most promising approaches to dealing with noise is to delocalize the quantum information used in the computer. This is because the noise that creates problems is typically local. The idea is to delocalize where the information is stored, and the researchers developed a new way to do that.

Inside a quantum computer are superconducting circuits—their states can be described using pairs of electrons known as Cooper pairs. In such systems, the pairs tunnel through a Josephson junction. The researchers came up with a new kind of superconducting qubit in which the quantum states are nonlocalized by modifying the Josephson junction. In their setup, two Cooper pairs were allowed to tunnel through simultaneously. The junction was made using a superconducting loop that also made use of superinductors. Using this approach allowed the team to control the kinetic interference co-tunneling element. This resulted in suppressing the tunneling of undesired Cooper pairs, allowing those that were co-tunneling to pass through unharmed. The approach led to doubling the magnification of the superconducting phase.

The system exhibited a 10-fold reduction in the sensitivity of the qubits to noise. The researchers plan to test adding a quantum phase-slip to their system. This would allow for noise reduction in both phase and charge spaces, providing a much higher degree of protection.

More information: W. C. Smith et al, Magnifying Quantum Phase Fluctuations with Cooper-Pair Pairing, *Physical Review X* (2022). DOI: 10.1103/PhysRevX.12.021002

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