

Quantum Physics You Can Touch

Scientific Essay

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You might have heard that this year's Nobel Prize in Physics was awarded for something you can actually hold in your hand. Not a black hole, not a new particle, but a physical circuit—built, cooled, and tested in a lab. The winners, John Clarke, Michel Devoret, and John Martinis, did something once thought impossible. They showed that the strange laws of quantum mechanics, usually confined to atoms and subatomic particles, can govern a tangible piece of hardware. In their superconducting chip, quantum mechanics did not merely survive, it thrived.

To understand the significance of their work, we need to recall how quantum behavior usually works. In the microscopic world, particles like electrons can tunnel through walls, exist in two places at once, and absorb energy only in discrete amounts. But all of this was thought to vanish at larger scales. A grain of sand does not tunnel through glass. A baseball does not exist in a superposition of paths. As systems grow larger, classical physics takes over, washing out the quantum weirdness through interference, temperature, and sheer complexity.

But not in this chip.

The trio built what is known as a Josephson junction. It sounds simple: two superconductors separated by a thin insulator. According to classical physics, no current should pass through this barrier. But at temperatures near absolute zero, electrons paired into what are called Cooper pairs began behaving not as individual particles, but as a unified quantum wave. And that wave did not care about classical rules. It tunneled.

In essence, they observed macroscopic quantum tunneling. Like throwing a ball at a wall and seeing it reappear on the other side without ever breaking it, the electrons jumped the barrier—not by brute force, but by probability.

And this was not just an isolated blip. It was reproducible, measurable, and matched precisely what quantum theory predicted.

To isolate these effects, the researchers operated their circuits at temperatures below 100 millikelvin. At such extremes, thermal noise fades away, allowing fragile quantum effects to emerge. They gently pushed current through the junctions, staying just below the threshold where classical switching would occur. Still, the circuit flipped, not from heat, but from quantum tunneling. The transition rate matched the predictions for a collective quantum phase variable escaping a potential well. In short, the system behaved like a giant artificial atom.

And that analogy was not metaphorical. By firing carefully tuned microwave pulses into the circuit, they detected energy absorption in discrete steps, just like in hydrogen atoms. The superconducting chip could only absorb energy in set amounts, reflecting the quantization of energy levels inside its potential landscape. This quantization was not abstract, not simulated. It happened in real hardware, in a circuit etched onto a silicon chip.

Even more astonishing, the electrons inside the device acted coherently. That is, instead of behaving like many independent particles, they moved in synchrony, like dancers in perfect formation. This coherence is what makes quantum computing possible. It means that information can be stored, manipulated, and entangled in quantum bits—or qubits—without instantly falling apart. Their device proved that such coherence is achievable at scales far beyond isolated atoms, pushing quantum behavior from the realm of the invisible to the engineering lab bench.

This was not just a laboratory curiosity. The implications are massive. Superconducting circuits like the ones pioneered by Clarke, Devoret, and Martinis now form the foundation of today's leading quantum computers. These are not speculative technologies. Companies and research labs around the world now build processors from arrays of Josephson junctions, exploiting their quantized energy levels and coherence to perform computations that would overwhelm classical machines. The fact that such processors work at all rests on the shoulders of these experiments, which turned quantum physics into engineering.

More broadly, their work redefines where quantum mechanics applies. It is no longer a theory restricted to the tiny. It is a toolkit for building. If electrons can tunnel as a collective wave across micron-scale circuits, if energy can remain quantized in systems with billions of particles, then the classical-quantum boundary is far more flexible than we imagined.

There are philosophical consequences, too. The experiment challenges our intuition that quantum effects belong only to the strange, tiny world. It shows that under the right conditions, those effects can scale, become visible, and even useful. It suggests that the emergence of classicality from quantum laws is not due to some fundamental limit, but to environmental noise and decoherence, both of which can be engineered around.

Still, this is only the beginning. These superconducting devices, delicate and powerful, remain susceptible to loss and error. Efforts are now underway to extend their coherence times, to correct their mistakes, to link more of them together into scalable quantum architectures. But the foundation is already there, built on real circuits where quantum mechanics is not just a theory, but a working principle.

What Clarke, Devoret, and Martinis gave the world is not just a chip. It is a demonstration. A proof of concept that the rules of the quantum world do not stay locked away in the atom. With the right design, the right temperature, and the right insight, those rules can be brought out, amplified, and put to work. They turned theory into technology, and in doing so, made the quantum world something we can touch.