The Cat's Out, the Circuits Are Quantum!

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Abstract:

For over a century, quantum mechanics has shaped our understanding of the microscopic world that governs atoms, electrons, and photons. Yet, it long seemed that quantum phenomena would remain confined to this tiny domain, forever hidden from our everyday experience. The 2025 Nobel Prize in Physics shattered that boundary, recognizing experiments that revealed unmistakably quantum behavior in macroscopic electrical circuits built from superconductors.

This talk traces the remarkable journey from the birth of quantum theory to the observation of quantum tunnelling in man-made, millimeter-scale systems. We begin with the early quantum revolution – Planck's quantization, Einstein's photons, Bohr's atom, and Schrödinger's wavefunction – culminating in the concept of quantum tunnelling. We then move to the emergence of collective quantum states, where electrons in superconductors form Cooper pairs that share a single macroscopic wavefunction. At the heart of the story lies the Josephson junction, a thin barrier between two superconductors that allows Cooper pairs to tunnel coherently. This device became the stage on which physicists such as Clarke, Devoret, and Martinis demonstrated macroscopic quantum tunnelling and quantized energy levels in electrical circuits, the achievements honored by this year's Nobel Prize.

Finally, we explore how these phenomena underpin modern quantum technologies – from ultrasensitive sensors to the superconducting qubits that now power many quantum computers. In short, Schrödinger's cat has finally left its box – not in paradox, but in the form of circuits that think in superposition.

Profile:

Dr. Siddharth Dhomkar is a physicist interested in uncovering the quirks of the complex world around us. He completed his undergraduate and master's studies in Physics at the University of Pune, after which he pursued his passion for teaching as a high-school teacher for two years. He later earned his Ph.D. from the City University of New York, where he investigated magneto-optical effects in quantum structures and their potential use in devices such as solar cells and lasers. His first postdoctoral position at the City College of New York focused on diamond defects for applications ranging from memory storage to quantum sensing. He then spent over four years as a senior research fellow at University College London, where he helped establish a state-of-the-art laboratory that employs optical spin defects for nanoscale sensing and quantum information processing. Beyond his work in quantum physics, Siddharth is keen on applying artificial neural networks to tackle intricate problems in physics. Since 2022, he has been a faculty member in the Department of Physics at IIT Madras and an Honorary Research Associate at University College London.