From Macroscopic Quantum Coherence to Superconducting Quantum Computers

Yasunobu Nakamura[1,2]

[1]*RIKEN Center for Quantum Computing, Wako, Saitama 351-0198, Japan*

[2]*Department of Applied Physics, Graduate School of Engineering, The University of Tokyo, Bunkyo-ku, Tokyo 113-8656, Japan*

We are pleased to celebrate the 80th anniversary of the foundation of the Physical Society of Japan. The year 1946 was right after World War II, about 30 years after the birth of general relativity and 20 years after the establishment of quantum mechanics. It was even before the invention of a transistor and a decade before the BCS theory of superconductivity. We appreciate that our science and technology have made so much progress since then and contributed (hopefully in a good manner) to the development of human society.

Quantum mechanics has always been puzzling to everyone: It works "for (almost) all practical purposes", while the very basic concepts, such as superposition, entanglement, and projection, are simply beyond our perception. So, it was natural that people, like Erwin Schrödinger, asked a question about why we do not see any evidence of superposition or coherence in macroscopic objects. Around 1980, Anthony Leggett proposed using a superconducting electric circuit to demonstrate a superposition of two distinct states of the circuit, which led to the demonstration of a superconducting qubit in the late 1990s. Coincidentally, ideas of applying the principles of quantum mechanics to information processing, including quantum computing, emerged as quantum information science around the same time.

Thanks to accumulated knowledge and drastic technical advances since then, small-scale superconducting quantum computers, together with quantum computers in other modalities, have been built and operated by many groups worldwide. Exciting proofs of principle are being reported every week these days. However, they are still in their infancy, and many challenges remain to be overcome before we realize large-scale fault-tolerant quantum computers. At the same time, building a quantum system with many degrees of freedom and with full control of the states in its large Hilbert space is an ultimate dream of quantum physicists and engineers.

The Physical Society of Japan
International Symposium on 80th Anniversary