The mysterious nature of quantum bits

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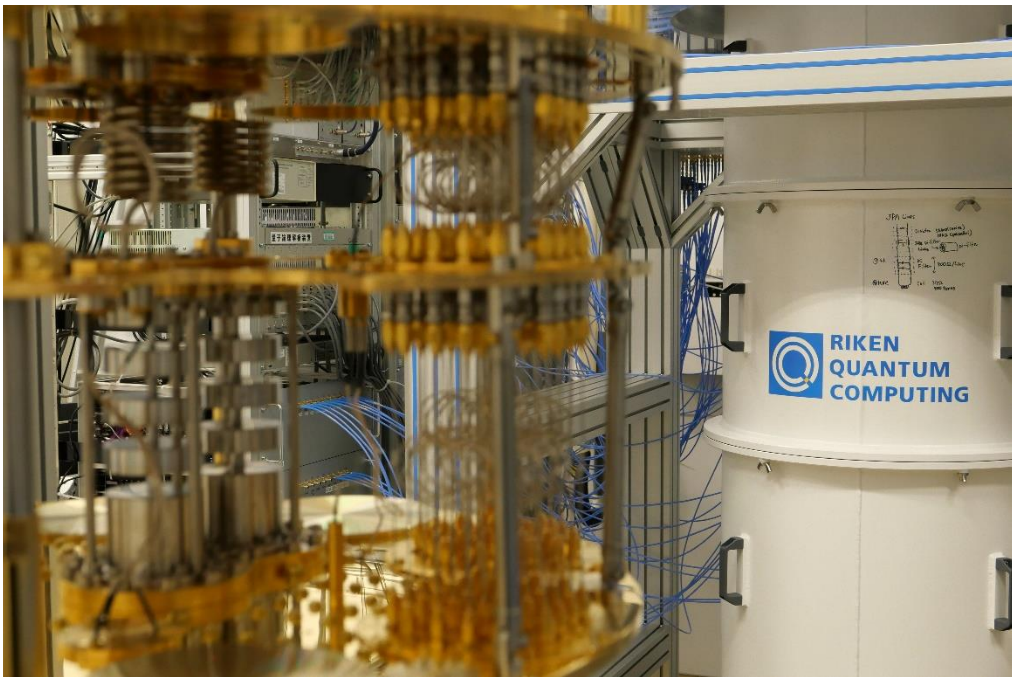

Figure 1. A dilution fridge used for superconducting qubit experiments.
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Have you ever heard of the word “quantum computer”? I am a graduate student working on building a quantum computer, a computer that could revolutionize our lives. In this letter, I would like to share with you 1. why I decided to become a scientist, 2. what I am doing, and 3. how my research will improve our lives in the next 10-20 years.

1. What inspired me to do research in this field.

I became a scientist because I was fascinated by the power of physics that unveils mysteries behind the nature and gives us the ability to predict the future.

My first encounter with physics dates back to my elementary school years. When I was in elementary school, slightly younger than you, I was always wondering how things around us worked: lights, cars, microwaves, and even universe. Once, I tried to replicate an IH (inductive heating) cooking heater. I read several books on electrical circuits, looked through DIY websites and asked my parents for help. Of course, it did not go well on the first trial, but every time the circuit I made did not work, I could always find a physical explanation why it was wrong. That was when I realized the unquestionable predictive power of theories based on physics.

I first learned about the field of “quantum computation” when I was a junior high school student. It was in 2011, when a US company called D-wave announced the world’s first device based on the principle of quantum mechanics. It was then that I learned about "quantum computing" and that it consisted of "qubits”, and it uses "quantum superposition" of 0 and 1. As a kid, I did not understand much about the terms they used. But since then, I have been captivated by the imaginative application of physics and started aspiring to become a researcher in the field of quantum computation.

2. Open scientific question in my research field.

The field of quantum computing is mystifying and often counter-intuitive. We use a “qubit”, a quantum counterpart of a classical bit. This is the fundamental building block of quantum computers. Unlike classical bits, which represent either 0 or 1, qubits can exist in multiple states simultaneously, thanks to the quantum phenomenon called “quantum superposition”. Quantum superposition enables quantum computers to perform complex calculations at speeds unreachable by classical computers.

Research towards the realization of quantum computation is gaining more and more momentum these days. Not only are academic groups like ours, but some industrial companies are also starting projects on quantum computers. Different research groups are working on different platforms to realize a superconducting qubit. The platforms can be a semiconductor, superconductor or atoms.

However, it remains an open question for all of the platforms as to how to “scale” the number of qubits. The true quantum speedup is achieved only if we put together millions of qubits in a stable and reliable manner. One problem preventing the scaling of qubits is the very nature of the qubits. The quantum state is so fragile that it can be instantly broken (in far less time than you blink!). The qubits and the noisy surrounding fields are constantly interacting. The quantum state experiences noise from such as vibrational modes on the surface and cosmic rays.

A vast amount of research is dedicated to how to protect precious qubits from noisy environments. One approach is “quantum error correction”. This involves putting together several physical qubits to work as a single “virtual qubit” that effectively experiences no environmental noise. Our major challenge with superconducting qubits now is how well we can combine several physical qubits. Unlike classical bits, however, qubits are really fragile and it’s difficult to make good qubits simultaneously. However, we believe the greater the challenge is, the greater the sense of achievement when we succeed in building them. We are enjoying our research very much.

3. Why it matters.

Quantum computers provide exponential speed-ups in multiple tasks compared to classical computers. Quantum computers can change the way we live in many ways. This revolutionary technology is not just an abstract concept: it holds practical significance for everyone, including junior high school students like yourselves.

One of the most certain and impactful applications of quantum computing lies in the field of medicine. Quantum computers are by nature, good at simulating the behavior of molecular reactions. The exponential speed-up capabilities of quantum computers will accelerate the drug discovery process, offering hope that diseases currently incurable might be curable in the near future. The impact of developing new medicines is so drastic that you may be able to live a disease-free life in the future.

Furthermore, quantum computers can solve complex optimization problems much more efficiently than classical counterparts. This ability can be applied to enhance urban planning and logistics. For example, by optimizing traffic flows and public transportation schedules, quantum computers may significantly reduce congestion in cities. Imagine a future where your daily commute to school or weekend trip is free from the frustration of overcrowded buses or infinitely long traffic jams at highways. The deployment of quantum computers for urban planning promises a smoother and more efficient life in cities.

But performing these practical tasks requires millions of qubits, so we need wait a little bit longer until that time.

Finally, the diverse applications of quantum computers will surely change the way we live in the near future, from healthcare to daily commuting. The research of quantum computers is full of excitement and at the same time essential to a better society.

Note:

I used Grammarly and ChatGPT for spellcheck and smart wording.