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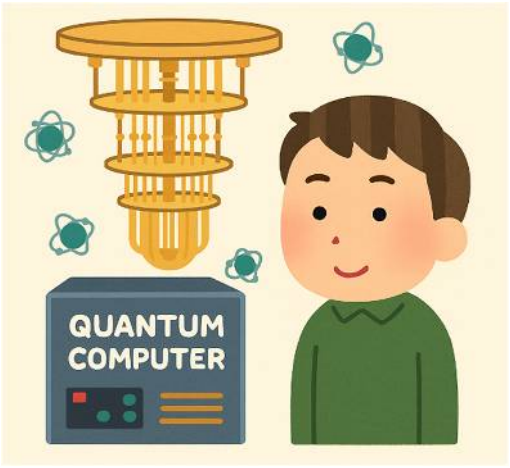
Essay by Manaki ARIHARA

title: Quantum Computers: The Next Big/Little Thing



Have you ever heard of quantum computers? If you haven't, that's perfectly okay. In fact, many people are not familiar with the word "quantum" either. "Quantum" is a term used in science when we talk about how very small things—like atoms and molecules—move. These things follow special rules called quantum mechanics. They are so tiny that we can't see them with our eyes.

What makes them fascinating is that they don't behave like everyday objects. For example, a tiny particle doesn't have a clear position or speed until you observe it. That may sound strange, but it's one of the key ideas in quantum mechanics. Even after you observe it, the result isn't just random—it's determined by probability, or the chances of something happening.

These rules are very unusual, and even scientists sometimes find them hard to understand because they are so strange. One of the most important and mysterious ideas is

called entanglement. This means that two tiny particles can become linked in a special way. When two particles are entangled, checking the state of one of them immediately determines the state of the other—even if they are far apart, possibly on opposite sides of the universe. This strange connection between particles is real, and it has been confirmed in many experiments. I found this strange and wonderful behavior incredibly interesting. It's one of the biggest reasons I became interested in quantum computers. Quantum computers try to use these unique properties—like probability and entanglement—to process information in a completely new way. In other words, quantum computers are different from the computers we use every day. They don't just use the usual 0s and 1s like classical computers. nstead, they use something called qubits, which can be in more than one state at the same time. Qubits are kind of strange, but you can imagine them like a coin that's still spinning in the air — it's not just heads or tails, it's both at once. This weird feature helps quantum computers solve some problems much faster than regular computers.

So, what are quantum computers good at? There are specific problems they may solve much faster than regular computers (which we often call classical computers). Some examples include prime factorization, which means breaking a large number into smaller prime numbers, and searching problems, where the computer needs to find the correct answer from many possible options.

Prime factorization is especially important because it is used in cryptography—the system that keeps websites, online banking, and personal messages safe. If quantum computers become fast at solving this kind of problem, it could change how we keep digital information secure. But for now, quantum computers are still under development. They can't do everything

that regular devices like phones or laptops can do. Scientists are still testing them, improving their design, and learning how they work. That's why it is so important to figure out what kinds of problems quantum computers are best at solving.

My research is part of this growing field. I study how quantum computers can help us better understand how quantum systems behave. As I mentioned earlier, atoms and molecules follow the rules of quantum mechanics. If we can understand how these particles move and interact, we can do much more than just study physics—we could also develop new materials, invent useful technologies, create life-saving medicines, and explore many other exciting possibilities. However, simulating these quantum behaviors is extremely difficult for classical computers. They need huge amounts of memory and time just to handle small quantum systems. That's why quantum computers may be so helpful: they are naturally suited to solving problems about the quantum world. In my work, I try to find better ways to use quantum computers to learn more about how the world works at the smallest scales.

This is why I think quantum computers are so exciting. They are not just based on deep and beautiful science—they also have the potential to help people in many ways. Once quantum technology becomes part of our daily lives, many people will have the chance to learn about "quantum," and it will fascinate them. We don't see them in everyday life yet, but I believe that's exactly why scientists need to keep pushing forward right now.

Maybe you're just starting to fall in love with physics. If so, I hope you keep being curious and try to explore more fields and meet different kinds of people who also love science. I didn't discover how cool quantum computers are until I got into college. When you were 12,

you were really into particle physics, and maybe didn't care much about other areas of physics. But if you had looked at other topics too, I think you would have had even more fun learning physics — and it would have helped you a lot later. Also, try to read not only science books but also novels and books about history, people, or ideas. You've always loved science, so maybe you didn't read much outside of it. That might sound strange, but reading those kinds of books can help you grow as a scientist, too. Now, I don't have enough time to read as much as I want — I wish I had read more when I was your age.

One more thing — try to meet other people who love the same things you do. Maybe at school or in your club, there aren't many people who like physics, and sometimes you might feel like you're the only one. But now that I'm in graduate school, I know that there are many people all over Japan — and the world — who are just like you and love science! You might be a little shy but try to take that first step. There's a future waiting for you that's more exciting than you can imagine.

I appreciate for the useful advice from Kansuke Sasamori, nice peer reviewer and instructor Mark Vagins. This essay is revised based on them.
I used Chat GPT to check my writing and create the image.