Counterintuitive Properties in Quantum Mechanics and How We Can Apply Them to Everyday Life

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I'm a researcher in quantum information. Quantum information is based on quantum mechanics, so let's start with explaining quantum mechanics. Quantum mechanics is the law for things in the world at an incredibly small scale, about one ten-billionth the size of our bodies. This scale difference is like that between the entire Earth and one grain of sand. The laws in quantum mechanics are completely different from the ones we see in our everyday lives, often going against our intuition. For instance, there is a property called the "superposition principle". Instead of an electron being at a specific position, it might exist in a "superposition" state, e.g. 30% likely to be at one place and 70% at another. It is something that is not observed at the scale of our everyday lives. If this were to be observed on the scale of our everyday lives, we would have the following funny situation: Imagine if you and your friend were sitting on a bench. With the superposition principle, it would be possible for your friend to be sitting 30% on your right and 70% on your left. This doesn't mean that your friend is still deciding where to sit; they are already sitting, but where they are exactly hasn't been decided until it's checked. Although this analogy is not technically accurate in all aspects of superposition, it helps illustrate its concept. The superposition principle cannot be observed in our daily life, but it actually happens in the tiny-scale world governed by quantum mechanics.

Then, the field of quantum information uses these strange properties of quantum mechanics to develop a completely new computer called a quantum computer, which performs calculations in a completely different way from the computers we have today. Our traditional computers use "bits" to process information, which are always in one of two states: 0 or 1. Quantum computers, however, use "qubits" to process information. A qubit can be in a superposition of 0 and 1, just like the analogy of the friend on the bench being 30% on your right and 70% on your left. This superposition allows a qubit to be in states that are not possible with a bit, enabling quantum computers to perform more complex calculations within them that are impossible for

traditional computers. Thus, quantum computers might solve some types of problems more efficiently than traditional computers.

One of the biggest challenges with quantum computers is figuring out how to extract the necessary information from the superposition state inside a quantum computer. Even if the desired answer is expressed using superposition states inside the quantum computer, the answer cannot be retrieved directly from the quantum computer. This is due to another curious law of quantum mechanics: it is not easy to know the details of the superposition state, i.e., with what percentages 0 and 1 are in their superposition. With the current technique, it takes a great deal of effort to know the details of the superposition state. Thus, even if the calculation itself is done efficiently, it takes time to retrieve the answer. Solutions to this are being considered from various aspects. One approach is to use the superposition state as the input of the successive calculation within the quantum computer, only retrieving the answer when it can be expressed without superposition state at the end.

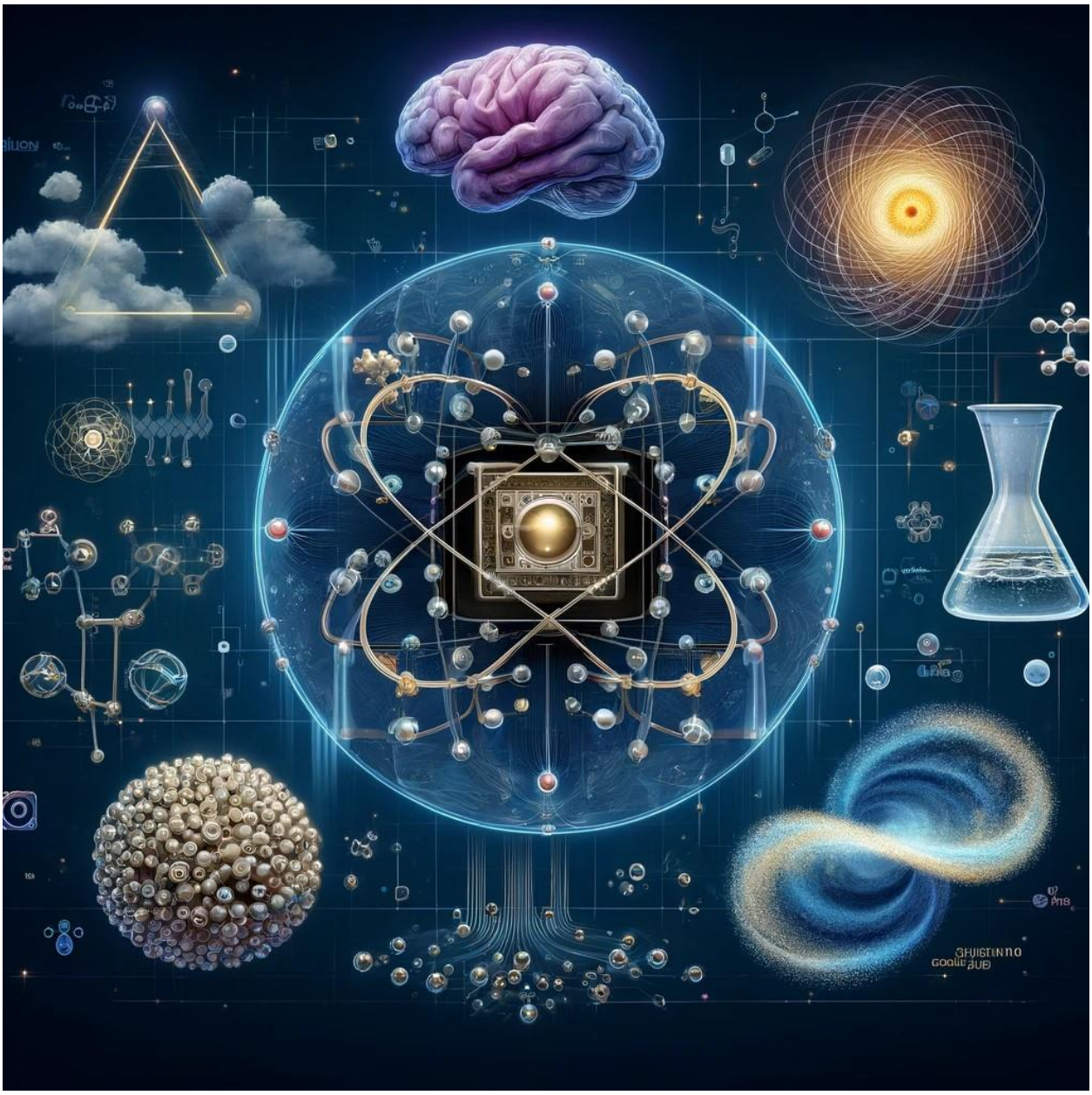
The reason I wanted to become a researcher in quantum information is that I can touch the mysterious structure of this world and at the same time see how these mysterious laws are useful to society. As we have seen, among the many laws of physics, quantum mechanics is one of the laws that is very far removed from our intuition. These are not merely mysterious phenomena such as psychic phenomena but are deeply related to how this world is structured. As we use the laws of quantum mechanics in the research on quantum information, we often find results that differ from our intuition and experience the wonder of how this world works. At the same time, I feel that the ability to utilize these mysterious laws in computer calculations is an interesting aspect of quantum information. If it becomes possible to use these mysterious laws in computer calculations in a way that goes against our intuition, it will be truly magical and must be very exciting.

Quantum information research has the potential to create more efficient computers, potentially changing our lives in a few decades. As explained earlier, quantum computers can perform complex calculations inside them using superposition states, and thus have the potential to complete tasks that current computers cannot handle in a realistic amount of time. An example

is machine learning, which has attracted attention for generative AI. It may be possible to create more knowledgeable AI by processing much larger datasets much faster than current computers. This could lead to AI systems that are better at understanding and responding to complex questions, making them more useful in fields such as education, healthcare, and customer service. Another area is the simulation of liquid or airflow. If quantum computers can simulate liquid and airflow more precisely, we could build faster and more fuel-efficient ships, aircraft, and cars by reducing liquid and airflow resistance. This would not only save energy but also reduce environmental impact, contributing to a more sustainable future. Additionally, the simulation of chemical reactions is another expected field. Since most of the internal workings of the human body involve chemical reactions, more precise simulations could be crucial in developing new drugs and treatments. By discovering new interactions between drugs and the human body, we might find more effective treatments for various diseases, improving healthcare outcomes and potentially saving lives.

In conclusion, the strange and surprising properties of quantum mechanics can lead to amazing new technologies. Quantum computers might help us create smarter AI, build better vehicles, and find new medicines. By conducting research on quantum information, we can learn more about the world and develop tools that improve our daily lives.

(ChatGPT and DeepL are used to refine the sentences.)



(Image made by DALL-E, an AI for generating images by OpenAI.)

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