Why I Dived into the Microscopic World

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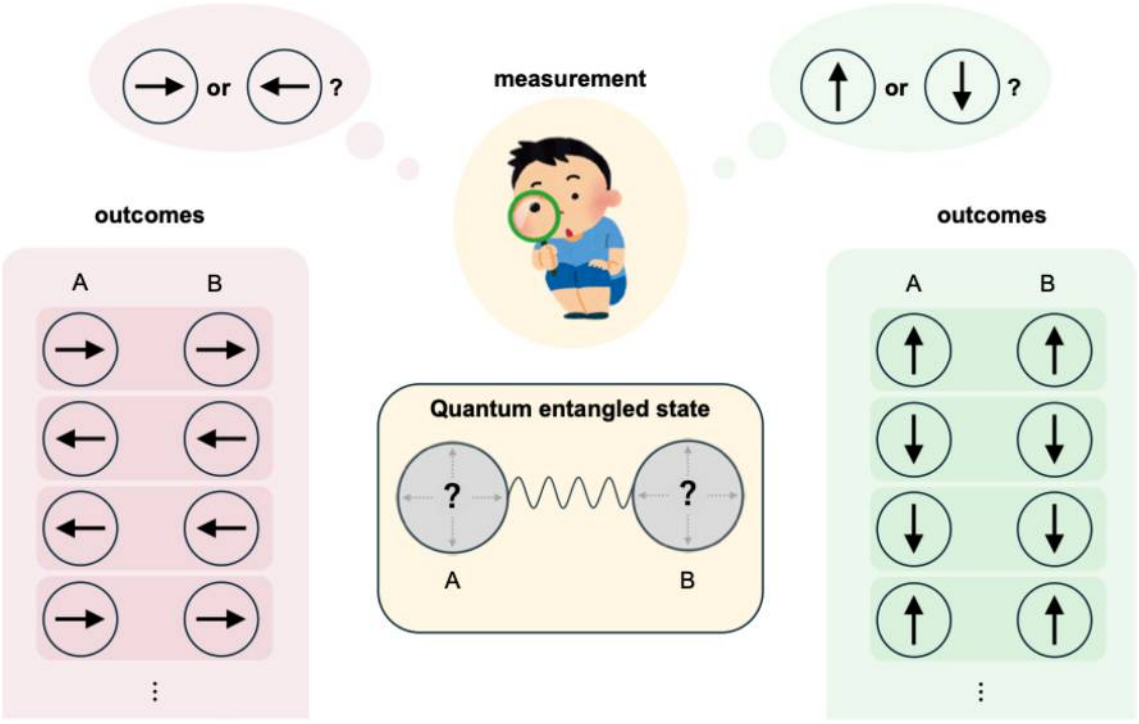

What does the microscopic world look like? — Have you ever wondered what everything around us, including ourselves, is fundamentally made of? Modern science has revealed that all matter consists of atoms, which are incredibly small — in fact, they are about 10^{-10} meters in diameter. In such a microscopic world, physical phenomena are governed by a fundamental theory called *quantum mechanics*.

In the quantum world, many phenomena occur that sharply contrast with our everyday experiences. For instance, if we prepare two objects similarly, we expect that measuring them will always yield the same outcome. However, in quantum systems, even identically prepared particles can give different results when measured. This is not due to experimental error, but rather reflects the probabilistic nature of quantum mechanics. By "probabilistic," I mean that we can only predict the likelihood of different outcomes, not the exact outcome itself. This is because a quantum particle can exist in a *superposition* — a combination of several possible states at once — until a

measurement is made, at which point it randomly "collapse" into one specific outcome.

An even more counterintuitive phenomenon arises when two or more particles become *entangled*. Quantum entanglement is a physical condition in which the states of multiple particles are so deeply correlated that the state of one cannot be described independently of the other, even if the particles are separated by vast distances. When a measurement is performed on one particle, the state of the other particle changes instantaneously, regardless of the spatial separation between them. This challenges our intuitions about locality, yet has been verified in numerous experiments.

Since all matter is composed of countless microscopic particles, entanglement should exist even in ordinary materials. The purpose of my research is to understand the structure of quantum entanglement in physical systems and how it changes when we perform measurements. Through my study, I aim to gain a deeper understanding of the fundamental nature of quantum entanglement and shed light on the future of quantum technologies, as I will explain later.

What motivates me to study quantum mechanics? — The primary reason for my research into quantum mechanics is its inherent scientific fascination. Even familiar materials around us can reveal a mysterious world governed by quantum mechanics when we examine their microscopic components. Indeed, we often encounter results that defy our everyday intuition when we analyze their behavior based on quantum mechanics. Remarkably, however, these predictions can be confirmed through experiments. By building upon these findings, we will gradually come to understand the true nature of the universe.

However, the strange world of quantum mechanics is not merely fascinating—it is also expected to reshape our society dramatically in the coming decades. In fact, by

harnessing concepts such as *superposition*, *quantum entanglement*, and even *measurement*, researchers have discovered ways to perform complex calculations far faster than any conventional computer and to develop cryptographic methods that are fundamentally secure against eavesdropping. In particular, the realization of a quantum computer will be of immense benefit to us because it could help us predict the intricate three-dimensional structures of proteins for drug discovery, forecast stock market fluctuations to avoid financial risk, and simulate complex weather patterns to anticipate large-scale natural disasters.

This year marks exactly one hundred years since the birth of quantum mechanics. Over the past century, our understanding of the once-mysterious quantum world has advanced dramatically. In the next hundred years, we will likely see a deeper understanding of quantum systems and rapid progress in applying quantum mechanics to develop society. In this way, quantum research provides an ideal arena for both the fundamental exploration of the universal laws of physics and the engineering challenges in solving real-world problems.

A piece of advice for future scientists — It is often assumed that becoming a scientist requires exceptional talent from an early age—reading extensively as a child, excelling academically, and impressing others with flashes of insight. While some well-known historical figures such as Albert Einstein and Marie Curie fit this image, many others do not. In my case, I was an ordinary child who preferred writing and composing music, and I never imagined pursuing science as a career. My interest in science developed gradually through experiences in university and while considering my future path. I believe this is also true for many of my peers in graduate school who aspire to become scientists. Even if you struggle academically, you don't need to be discouraged by that.

Becoming a scientist is not solely dependent on innate ability.

What scientists do share is strong curiosity. It is not about having all the answers, but about enjoying the process of asking questions. If something makes you wonder "why?", try asking a teacher, reading books, or exploring it on your own. If that process feels enjoyable, you may already be taking your first step toward scientific thinking. Even when clear answers are not immediately available, maintaining that curiosity is what drives discovery forward.

For those interested in what real scientific research is like, I encourage you to participate in outreach programs like public lectures and open laboratories offered by universities and research institutes. Some programs even allow secondary school students to participate in research activities. You need not worry about lacking knowledge — scientists welcome anyone who comes with genuine questions and curiosity.

Through these experiences, you may realize that science is not a distant world for a few special people but is rather deeply connected to our society. From medicine and technology to environmental and space sciences, research plays a central role in solving real-world problems. If you remain curious and continue asking questions, you may one day contribute to shaping a better future through science!

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