Why I explore the Quantum Wonderland

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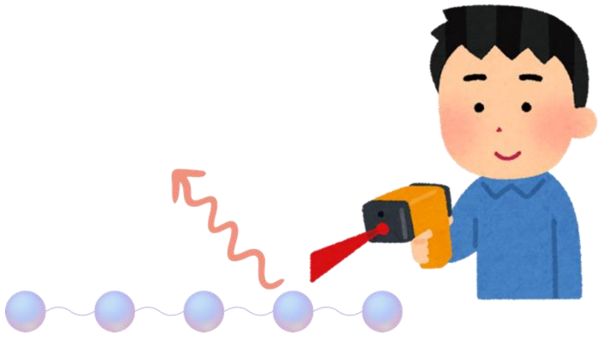
Enigma of measurements in quantum mechanics. – "Do you believe that the moon exists only when you look at it?" Albert Einstein used this famous question to emphasize the incompleteness of quantum mechanics, the theory of the microscopic world [1]. While understanding that quantum mechanics correctly describes the world, Einstein still considered it incomplete. In what aspects of quantum mechanics did he take as incomplete?



In quantum mechanics, measuring a system and obtaining results are stochastic phenomena. In simpler terms, the system's state remains uncertain until it is measured. Upon measurement, it instantly collapses into a state corresponding to the result. For example, consider a particle moving freely in space. If you measure the particle's position as A, the particle after measurement is always at A and nowhere else. Furthermore, it's impossible to simultaneously measure particles' position and momentum and determine them to a certain state. These peculiarities, which defy our intuition, led Einstein to deem this theory incomplete, as it lacked what he referred to as 'elements of physical reality' [2].

On the other hand, in our daily lives, we can measure the position and speed of a ball whenever we want to, and the ball maintains its motion due to these measurements. This is the realm of classical mechanics, which provides a clear explanation for such scenarios. It doesn't explicitly state what happens when matter is measured. However, when it comes to quantum mechanics, the situation is starkly different. The assumption that one can measure physical quantities without affecting the measured object, a given in classical mechanics, becomes a significant issue in the quantum world.

While quantum mechanics may seem bizarre, numerous experiments have validated its precision. This precision of quantum mechanics prompts us to ponder questions like ‘How does matter behave after measurement?’ or ‘How much knowledge of the system can be gleaned from measurements?’ Particularly in substances with many particles, understanding measurement effects is an area ripe for exploration. With recent advancements in experimental techniques for manipulating the microscopic world, research in this direction has gained momentum. A deeper understanding of measurements in quantum mechanics not only promises to unravel the mysteries of the microscopic world but also holds the potential to shape future generations with new technologies.

What inspired me to do research in quantum mechanics? –Physics, like quantum mechanics, sometimes yields results that defy intuition. Whether one likes or dislikes this aspect may vary from person to person. I found myself drawn to the allure of facts that defy intuition but are confirmed by experiments. Quantum mechanics contains many results that go against intuition, making it a theory that even Einstein struggled with, which naturally piqued my interest.

Furthermore, for physics to describe the real world, it must also be able to explain the operations and measurements carried out by humans. However, theories other than quantum mechanics, such as classical mechanics, do not describe what happens to the state of the measured entity after measurement. Only quantum mechanics has been developed to include the measurement process in the theory. Moreover, its correctness and high precision have been confirmed by numerous experiments. Are there any other theories as precise as this?

Quantum mechanics still has many unexplored areas despite being such a precise theory. This theory, with its counterintuitive yet precise nature and lingering mysteries, motivated me to become a researcher. One of my goals is to shed light on some of these mysteries through my research and develop technologies that can be applied in the future.

Dreaming of a world with advanced quantum technology. – It's been about 100 years since the birth of quantum mechanics. Yet, humanity still hasn't fully grasped it or gained the ability to manipulate the microscopic world at will. Rather than despair, this is seen as a hopeful dream—a belief that as we further advance our understanding of quantum mechanics and improve experimental techniques, we will encounter even more fascinating and useful phenomena. I believe the quantum world holds such rich properties.

If we could understand and manipulate the microscopic world as we please, we can anticipate society changing unimaginably. Quantum technology has the potential for such an impact. For instance, there’s ongoing development of quantum computers, which can perform calculations faster than ordinary computers using the properties of quantum mechanics. While they’re not yet practically usable, if achieved, they could efficiently handle various simulations and search problems and even break current encryption methods, among other astonishing applications. There may also be developments in quantum communication technology, enabling faster information transmission than the latest 5G communication. Thus, fundamental science holds vast potential applications capable of shaping society.

As quantum technology advances and becomes commonplace, people's perception of quantum mechanics will likely change. Currently perceived as mysterious and sacred, the quantum world will become more familiar and ordinary. People might not find it strange anymore to be told, "The moon only exists when you are looking at it."

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<References>

[1] A. Pais, Rev. Mod. Phys. **51**, 863 (1979), p.907

[2] A. Einstein, et al., Phys. Rev. **47**, 777 (1935)