From Celestial Wonder to Atomic Clock

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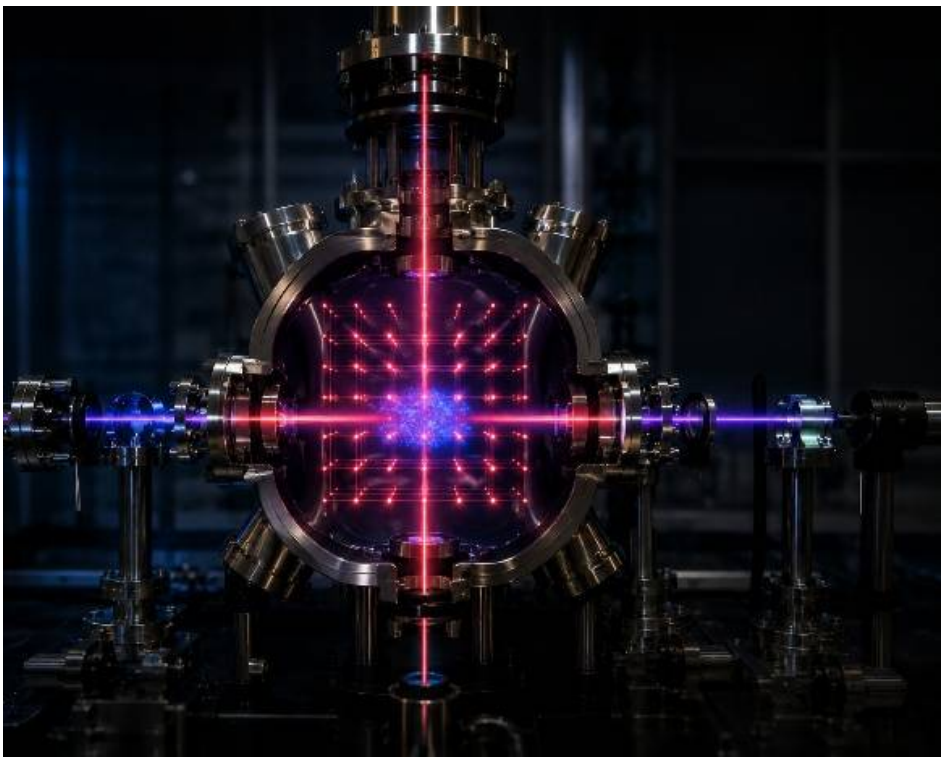

In the early morning on May 21, 2012, people in Tokyo observed an annular eclipse. I was one of the witnesses. For about an hour, the Sun looked like a glowing ring. This event had last been seen in Tokyo 173 years earlier, meaning that I might never see it again in my lifetime. Everyone wore special protective glasses to look safely at the Sun and enjoyed the rare event together from schools, streets, and parks across the city. I still vividly remember how the ring-shaped Sun appeared for only a brief moment through thick clouds. Rare and miraculous moments like this stimulate people's imagination and curiosity. Some people might see such an event as a sign of good luck. Interestingly, thousands of years ago, when people did not yet fully understand the movements of planets, eclipses were sometimes regarded as omens of disaster or signs

that the gods were upset. I was deeply intrigued by this phenomenon and wanted to understand the mechanism behind it. As a stubborn and curious child, I did not buy any of the superstitious explanations that were based only on belief. I wanted a logical explanation for this once-in-a-lifetime event. Since then, I have been obsessed with books about planets and space. Learning how the Sun, the Moon, and the Earth move and how they formed gradually drew me deeper into astronomy. I did not understand every detail at first, but little by little, my image of the universe began to take shape in my mind. Curiosity about the world naturally led me to wonder what lies beyond our solar system and even beyond our galaxy. I was mesmerized by pictures of the Milky Way stretching across the night sky and could spend hours reading books about stars and the universe.

I have always enjoyed understanding the world around us. My curiosity was not limited to the universe. I also wondered about everyday things, such as why some traffic lights are arranged vertically or why different months have different numbers of days. I believed there must be reasons behind these things and discovering them was exciting. I always wanted to share what I learned with my friends and family. This curiosity stayed with me through high school and into college. When it came time to choose my major, I did not hesitate. Although there are many practical fields that might be useful for my future career, curiosity has been the most important value in my life. I chose physics because the laws of physics are fundamental to everything in existence from planets to microbes. Everything in the universe follows these laws. To understand as much as possible about the world, knowledge of physics is incredibly powerful. Many complicated phenomena can ultimately be explained by a few simple but beautiful principles. That is why I was determined to pursue a career in physics. Behind every

scientific observation, there is a beautiful story waiting to be discovered.

Currently, I am working on developing one of the most precise clocks in the world. It functions as a clock, but it looks nothing like the watches or wall clocks most people imagine. Instead, it consists of a large vacuum chamber connected to a pump with a thick pipe and surrounded by countless mirrors, lenses and colorful lasers. Green, blue, and red laser beams flash periodically throughout the system, giving the laboratory a somewhat Christmas vibe. You might wonder how such a machine can measure time. A familiar example of a clock is a pendulum clock. A pendulum swings back and forth at a regular pace because gravity acts on it consistently. If something moves at a perfectly constant rhythm, we can use that motion to measure time. However, pendulums are not perfect because factors such as air resistance gradually slow them down. Our goal is to eliminate as many sources of error as possible. That is why our clock operates inside a vacuum chamber with almost no air. So, what plays the role of the swinging pendulum in our research? We use atoms, tiny things that we cannot see, which are the basic building blocks of all matter. Everything in the universe—including machines, our bodies and even the Earth itself—is made of atoms. Because atoms are universal and have simple models to explain their behaviors, they provide an extremely reliable way to measure time.

One of the greatest challenges we face is minimizing every effect that could disturb the atoms and reduce the clock's accuracy. Temperature changes in the vacuum box and the light entering the box are especially important factors. Nevertheless, our lab has already achieved a remarkable level of precision: our clock would lose or gain only one second over 30 billion years, which is even longer than the age of the universe.

Our goal is to continue pushing the limits of precision as far as possible.

Surprisingly, these clocks are useful not only for telling time. Because gravity affects the flow of time, extremely precise clocks can detect tiny changes in gravity. This means they could help monitor earthquakes, underground movements, and changes beneath the Earth's surface. In the future, such clocks might even help detect underground resources such as oil or valuable minerals. Research in this field is opening the door to many exciting possibilities, and I am thrilled to be part of it!

For young readers, let us explore the world of science! The more you learn about science, the more exciting it becomes to understand what you observe and, furthermore, predict what you will see. Whether it is the motion of atoms inside a vacuum chamber, signals arriving from distant galaxies, or an annular eclipse appearing in the sky before your eyes, science allows us to see these phenomena in a deeper way. The very question that motivates us is always simple: Why do we see what we see? This has guided me all the way from watching an eclipse as a child to exploring one of the world's most precise clocks today. I hope that you, too, will be driven by the wonders around you and will join the journey of discovery that our great ancestors have passed down to us.

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