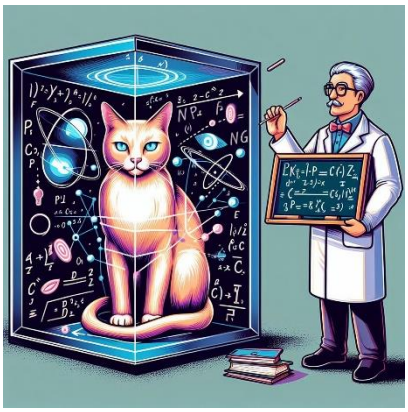
Why I Became a Quantum Engineer



My name is Nomura Takefumi. I am a Ph.D. student in the University of Tokyo, Faculty of Engineering, Applied Physics Department. My area of expertise is experimental quantum optics, aiming for the realization of optical quantum computers. I consider myself a physicist and an engineer. Therefore, my root source for motivation might be a little different from other researchers who do basic science.

Our modern way of life heavily relies on computers. Recent advances in hardware gave birth to things like ChatGPT. The demand for more computing capability has never been higher, and it will continue to grow. To meet this demand, faster, cheaper, and more energy efficient computers have been developed by integration and miniaturization. According to the famous Moore's law, the computational power will exponentially increase over time. The Moore's law held true. Now, the mankind can produce transistors as small as just a few nanometers! A marvel of human ingenuity! However, due to physical limitations, its rate of improvement is starting to stagnate. We require drastically different approach to make better computers. One of the proposed methods to meet the ever-growing demand is by optical quantum computers. It is a completely different method for computation that harnesses strange properties of quantum mechanics.

Quantum mechanics dictates physics in microscopic level, and it is vastly different from Newtonian mechanics. It has very counter-intuitive natures. For example, there is a famous thought experiment of "superposition" called "the Schrodinger's cat [1]." A cat, a flask of poison gas, and a radioactive material are held in a box. The box is opaque and any information about the state of inside the box cannot be obtained by the observer outside of the box. When there is a radioactive decay (intrinsically random event) and detected with a detection device, the flask will shatter and the gas will be released, killing the cat. But the observer cannot tell whether the cat is dead or still alive. In this state, the cat is considered neither dead nor alive to the observer. You may often encounter phrases like "the cat is dead and alive" in things like newspaper articles. This is not true. The cat is strictly neither dead nor alive. This state is called a superposition of dead state and alive state. Finally, once the observer opens the box, he will know and thus determine the cat's fate. This thought experiment states that a state (what is happening inside of the box) is a separate concept from the measured physical quantity (dead or alive). It is very different from Newtonian mechanics. I know it sounds strange, and you do not have to understand it right away. Its discovery in the early 20th century was a paradigm shift for the science community, and it stirred a lot of controversy back then. Honestly, I still do not fully understand it and came to just accept it. People can learn to follow the equation, but I believe no human being can ever intuitively understand it. Maybe you will if you become a scientist! But for now, in this essay, all you need to know is that there are strange phenomena with serious philosophical implication, and similar things are known to actually happen in microscopic level. When I took a course in basic quantum mechanics class as a graduate student, it changed how I viewed the world. After that, I decided to become a

researcher in this field. It was indeed the counter-intuitiveness that caught my interest. If the development of quantum computer succeeds and quantum mechanics become more familiar to the public, it might change how they perceive the world, just like it did to me as a graduate student.

Pure curiosity was not the only reason I became a researcher in this field. In the times of the industrial revolution, great advances were made in scientific fields such as control theory and thermal dynamics. One of the driving factors was the demand to make more efficient steam engines. Engineering and science have an inseparable relationship. The more we understand the world around us, the more we get to use it and better our lives, driving us forward as a specie. This holds true even today, just like how the demand to make better computers encourage us to make quantum computers. Quantum mechanics have worked very well explaining various physical phenomena. Unfortunately, there are only few examples of directly exploiting its strange natures due to technological limitations. Quantum computer is the prime example. They require manipulation of quantum states with a level of precision and scale incapable with current technology. Therefore, in my opinion, realization of practical quantum computers would be the ultimate achievements for quantum mechanics and a fine display of the mankind's ingenuity. Being a researcher and an engineer in this field is a direct contribution to that, which I feel deeply satisfying. I acknowledge my delusion of grandeur, but I must admit this thought strokes my ego.

Also, I absolutely love doing experiments. Things often do not go as planned, and you must make rigorous improvements to your experimental setup for it to work.

It is a long and arduous process. One simple problem (on hindsight) could hinder the progress for months! However, I still enjoy the challenge. Implementing your own ingenuity to the setup is like solving a big and complicated puzzle. When I finally manage to get it to work, I feel “nōjiru.” (I am sorry, I could not find an elegant enough translation that quite captures this Japanese word’s nuance.) The satisfaction! The feel of accomplishment! I am profoundly grateful to be able to do this as my job.

[1] Schrödinger, Erwin (November 1935), *"Die gegenwärtige Situation in der Quantenmechanik".* Naturwissenschaften. **23** (48): 807–812. doi:10.1007/BF01491891.

The image was generated with Microsoft Copilot, “A representation of Schrödinger's cat thought experiment.” Microsoft Word’s editor function was partially used to check spelling and grammatical errors. I thank Prof. Mark Vagins and Orii Ippo for reviewing my draft. Their reviews helped improve my essay greatly.