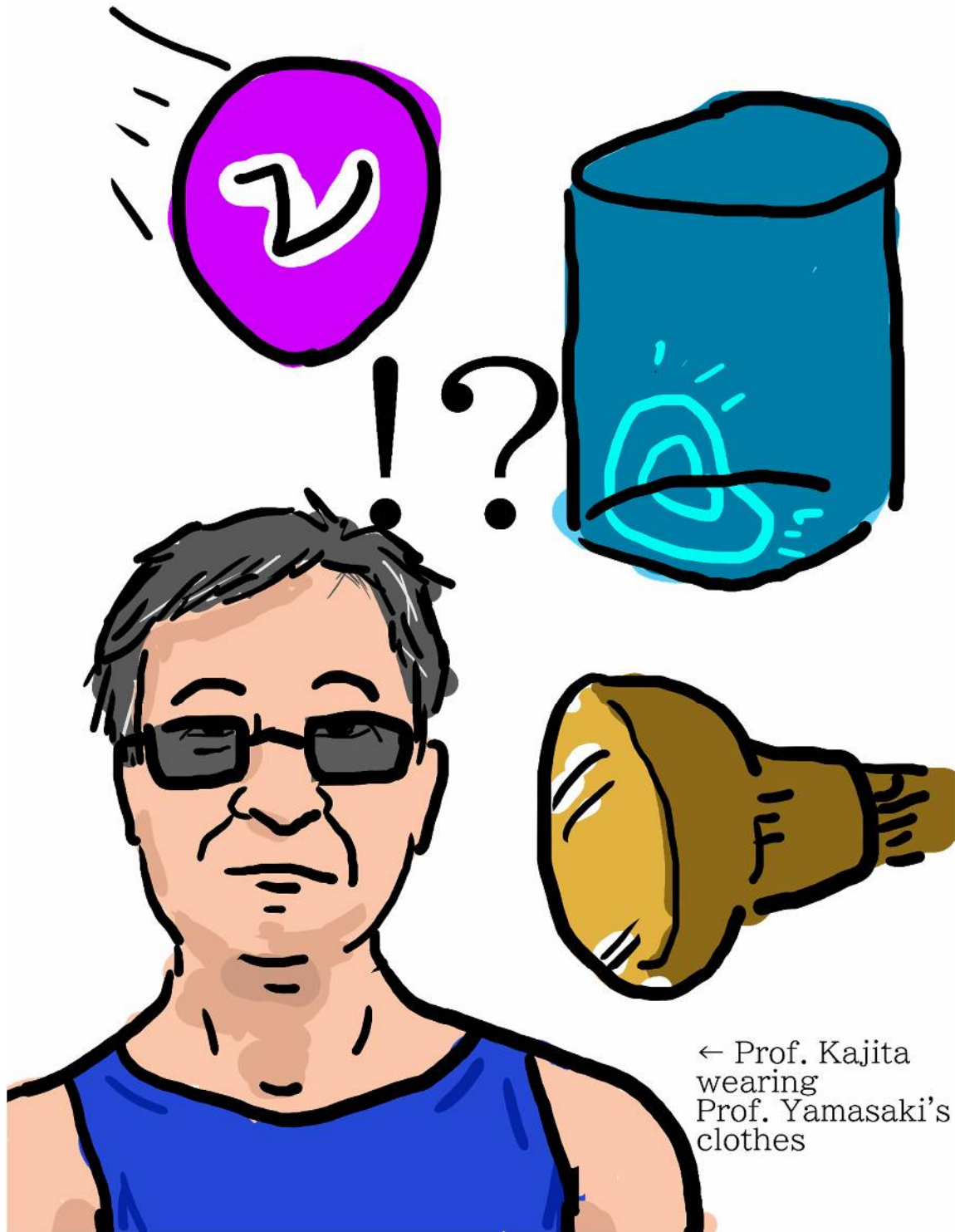


Mysterious Particle Neutrino

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[My Current Research and Why Do They Interest Me ?]

My current research is experimental elementary particle physics. The main topics are about Hyper Kamiokande and Neutrino Oscillation.

First, let me explain what experimental elementary particle physics is. Elementary particle is the smallest unit of matter, and it cannot be divided into smaller parts. So, everything in the world, including ourselves, is thought to consist of elementary particles. For example, the most familiar elementary particle is an electron. The ultimate aim of elementary particle physics is to understand the world by understanding the behavior of elementary particles. In other words, the spirit of elementary particle physics is that if we know all about the parts of something, we also know about the whole of the thing. I am working in experimental particle physics, so I would like to introduce an experimental one. Literally, experimental particle physics aims to understand elementary particles by conducting experiments.

I am currently interested in mysterious particles neutrinos. They are one of the elementary particles and belong to the same sector as electrons which are called lepton particles. There are three types of neutrinos, each corresponding to electrons, muons and tauons. Neutrinos are similar to electrons but different in electric charge. Neutrinos are neutral while electrons carry some electric charge. Neutrinos are thought to have many mysterious properties. This is why I am interested in them.

Let me tell you about neutrino flavor oscillation, one of their curious properties. The property is that a neutrino changes into another type of neutrino probabilistically while traveling over a long distance. This only occurs in the case of neutrinos. Additionally, if neutrinos had not have mass, the oscillation should not occur. Thus, the oscillation is evidence that neutrinos have non-zero mass.

Then look back on the history of neutrino research. In the beginning, neutrinos were discovered. At that time, neutrinos were thought to be massless particles and the standard theory of particle physics was built on that assumption. However, there was a problem that the prediction differs from the observation in the number of neutrinos that came from the sun.

In late 1990s and early 2000s, Prof. Kajita experimentally proved that neutrinos oscillate. This means neutrinos have slight but non-zero mass, and he helped solve the problem. This was astonishing. He won the Nobel prize for that work in 2015.

However, problems still remain. For example, the question of why neutrinos have non-zero mass is unsolved even today. Additionally, neutrinos are expected to have another strange property known as CP symmetry violation, which is related to the difference between matter and antimatter. This also has not yet been proven.

Second, I will introduce specific topics related to my research. My current research topics are about neutrinos and Kamiokande experiments.

So, what are we actually doing during particle experiments? It is quite simple. First, a physical event occurs. For example, two particles collide. Second, some particles are created and fly away. Third, we detect, or “see”, these particles that came out.

Although the concept of particle physics experiments seems simple, detection of neutrinos in an experiment is quite difficult. Because neutrinos are electrically neutral, they do not interact via an electromagnetic way. They interact only through the weak force and gravity. Therefore, they rarely react with matter. Almost all of the neutrinos pass through the detectors without any footage. This makes the observation extremely difficult.

Then, how can we “see” neutrinos? The answer is again simple: prepare tons of matter and wait for interactions. This is the principle of Kamiokande detectors. The massive water is used for this purpose.

Next, I will explain Kamiokande detectors. Kamiokande detectors are located under the mountain at Kamioka, the central part of Japan. The characteristic points of the detectors are their massive water tanks and large photomultiplier tubes which enable them to “see” phenomena in high sensitivity.

Currently, a new Kamiokande detector is under construction and I will work on this project for the next 2-3 years. The new detector is Hyper Kamiokande, the successor to Super Kamiokande. The volume of the water in Hyper Kamiokande is going to be nearly 10 times greater than that of Super Kamiokande. Therefore it is going to be more sensitive to physics phenomena.

Finally, I will introduce the T2K experiment, one of the largest neutrino experiments. The extraordinary point of the T2K experiment is that we create an artificial neutrino beam almost 300 km from Kamiokande and shoot it to Kamiokande! We then measure how neutrino flavor changes while they are traveling and seek proof of CP symmetry violation in the lepton sector.

In summary, I am very fascinated by the mysterious side of neutrinos and also excited by how giant the experiment is.

[Advice to 12 Years Old You]

I give you three pieces of advice. If I were in your place, I would do following:

- Always try to keep a curious mind
- Dive into chaos
- Study English

First, you should always keep a curious mind. That is good training for thinking about something logically. Additionally, that also can be a great motivation to study scientific subjects. Conversely, if you find you are bored while studying, then it may be a lack of curiosity. Try not to stop thinking.

Second, you should dive into chaos if you have such a chance. This is not my original advice. This is advice from Prof. Yamasaki of the Department of Physics in the University of Tokyo. Prof. Yamasaki once said “you dive into chaos, you crawl, you survive, then you have something in your hands which is definitely valuable”. I was moved when I heard that. If you want to achieve something, dive into chaos headfirst. He also said that chaos is the mother of order although they seem opposite. The doctrine of physics is unity and simplicity. So diving into chaos may also be the best way to develop true physical intuition.

Third, and finally, you have to study English. You can never study it too much. This is the most used tool for communication. English can drastically widen your world. It is very stressful if you are not able to use English freely when you try to interact with someone in English. In addition, more generally, learning a language is learning the ways of thinking shaped by the environment in which the language is spoken. From that point of view, too, learning English broadens your world.

In conclusion, if you follow this advice, you will build a confident and tough mindset.

I draw the picture by myself without AI.

I used generative AI for grammatical check.

I would like to say thank you to Kate Harris and Kenryo Sakoi for reviewing my essay.