Does the study of new elementary particles make our lives better?

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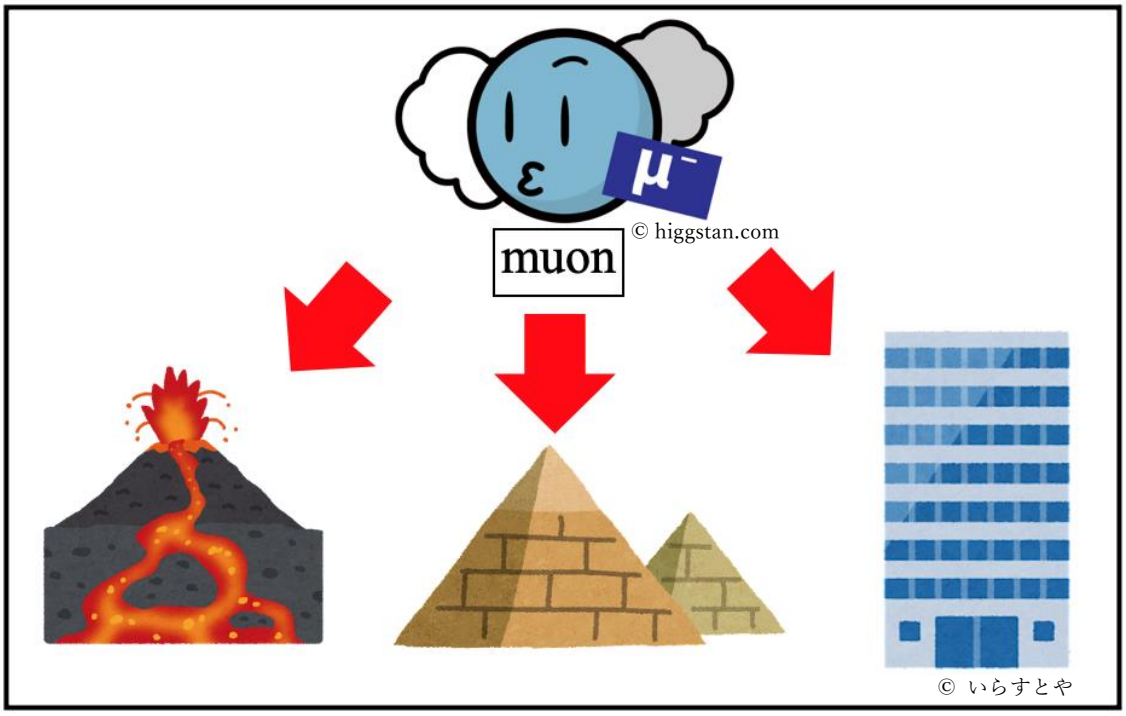

When you look up at the night sky, you realize that a significant amount of light from the universe reaches the Earth. However, do you know many radiations also arrive on the Earth at the same time? This fact was found by V. H. Hess for the first time in 1912. At that time, scientists had already known that a small fraction of molecules in the air are ionized and that this is due to radiation. However, they believed that the radiations came from the inside of the Earth. To test this hypothesis, Hess rode in a balloon, and he discovered that the number of radiations increases with altitude. These radiations are called cosmic rays. Since this time, many studies about cosmic rays were begun.

In 1932, a new particle was discovered; its name is muon. It's very similar to an electron. It has the same amount of electric charge which an electron has, and it can compose an element instead of an electron. They're produced when cosmic rays collide

with the atoms of nitrogens or oxygens in the sky and pass through your hand once per second. However, this particle may be known by few of you. This is due to the only one different point between muons and the electrons; a muon is about 200 times heavier than an electron. Because of this heavy mass, it easily breaks into lighter particles, and its lifetime is very short (two-millionths of a second). Thus, natural substances composed of muons soon collapse. Then, why are muons needed in this world? One researcher of that time said, “Who ordered that?”

To solve this mystery, much research has been conducted. As a result, another particle that is similar to an electron except for its mass was discovered. This is named tauon and its mass is about 3500 times as heavy as an electron’s. Thus, electrons have two types of particles that are very similar to themselves. They are called “charged leptons” collectively, and they are classified by “generation”. The lightest particle (electron) is the first generation, the second lightest particle (muon) is the second generation, and the heaviest particle (tauon) is the third generation.

This relation has been also found to be valid for other particles: “up quark” and “down quark”. They are known as constituents of protons and neutrons. A proton is composed of two up quarks and one down quark, while a neutron consists of one up quark and two down quarks. These two quarks belong to the first generation. The second and third generations of up quarks are called “charm quark” and “top quark”. They differ only in mass. The corresponding particles of down quarks are “strange quark” and “bottom quark”.

From some experimental results, it’s believed that there’s no fourth generation for each particle. However, it’s still unknown whether the number of the generations is really three and why that is three. Some promising theories say that the universe needs at least

three generations to become what it is today. The mystery of the number of generations is very important for the understanding of our universe and attracts many researchers even now.

On the other hand, since muons are hardly different from electrons and they easily collapse, you may think muons are useless in our daily lives. However, muons are now beginning to play an important role in some technologies now. Muon tomography is one of them. This enables us to take a picture like an X-ray image. Due to the heavy mass, muons are not easily bounced back by other particles like atoms. Thus, the most of muons produced in the sky can penetrate even a rock that is several kilometers thick and the number of muons that can penetrate a matter depends on its density. Therefore, by counting the number of muons, we can determine the density inside the substance. However, there’re many other non-destructive technologies that allow us to look inside. Why muon tomography is important? One of the advantages of this technology is the size of the sample we can probe. Indeed, using this technology, huge and unknown space was discovered in the center of the Great Pyramid of Giza [1]. Another research group succeeded in taking a video of the magma inside a volcano [2]. The information about the inside magma is expected to enable us to predict the eruptions more precisely.

Another advantage is the ease of the measurement. As mentioned above, many muons are always coming from the sky. Thus, all we have to do is set detectors near the samples. Thus, when the cost of the detector becomes much cheaper, this technology will be used not only in the research field but also in the industrial world. For example, we will be able to inspect the inside of the buildings more easily and precisely. Applying it to the examination of a blast furnace and a nuclear reactor is also being discussed.

We have seen the history of muons. Many researchers continue to search for new

particles. The discovery will surely enable us to get a better understanding of this world. However, when new particles have been just discovered, we have few technologies to use them. Thus, they can't change our lives soon and some people say such research is a waste of money. However, by continuing the study for a long time, we can get new ways of detecting and using their properties, which will make our lives better. Indeed, when the unknown space in the Great Pyramid of Giza was discovered, eighty-five years had passed since the discovery of muons. Although we can’t imagine what new particles will be found and what properties they will have, I believe they cause significant changes in our way of thinking and society. This innovative change is one of the attractions of particle physics as a fundamental science. If you are at all interested in this field, I want you to study it more by yourself. Many interesting topics are surely waiting for you.

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References

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