Supersymmetry: a new key to understand our world

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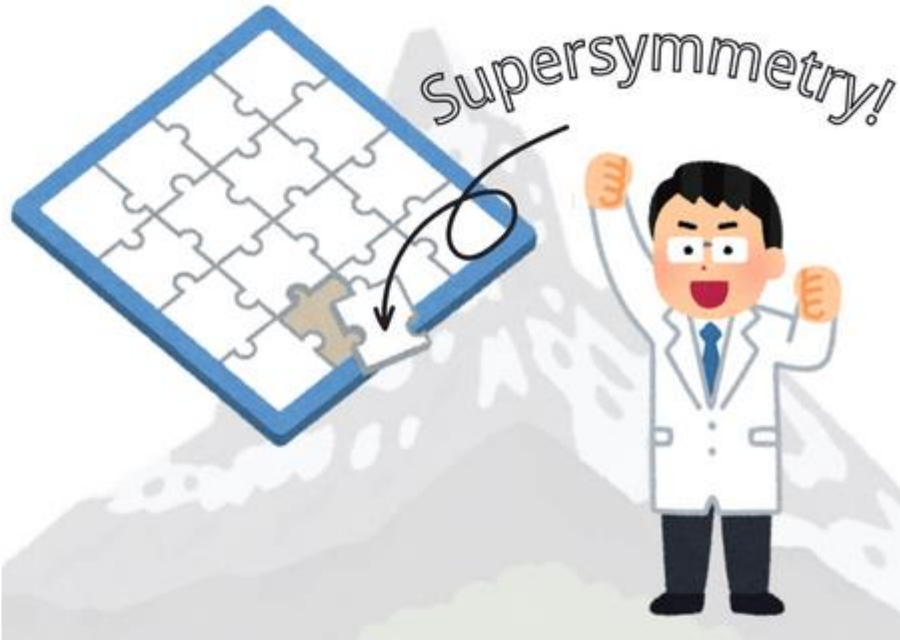

Have you ever heard of supersymmetry? It's quite a complex concept, so let's start with something simpler. What is symmetry? You might have heard about it in math classes. Imagine a circle: if you draw a line through its center, you can see that the left and right parts are “same”, meaning the circle can be folded in half along that line. This is called axis symmetry. If you rotate the circle around its center, it retains its shape, known as rotational symmetry. Thus, there are different types of symmetry in our world. Each represents something unchanged under a particular operation, such as folding or rotating.

Physicists want to find all kinds of symmetries governing our universe to see what rules are always unchanged in our world. It is just like solving a jigsaw puzzle----most of the pieces are already found, and the final missing piece is believed to be supersymmetry. To understand supersymmetry, we first need to grasp an important concept: spin. You can imagine particles that make up the universe as tiny magnets. Spin is like the strength of a magnetic force and is quantified as either an integer or a half-integer, where we call the former boson and the latter fermion. Supersymmetry is a concept that connects particles with bosons and fermions, much like the left and right parts of a circle. This intriguing relationship could provide the final symmetry needed to complete our understanding of the universe.

Unfortunately, there's currently no evidence showing perfect connections between bosons and fermions in the real world. This means that supersymmetry must be broken somehow or that it's merely theoretical. So, how can we prove that supersymmetry isn't just an illusion? If it exists, why haven't we verified it experimentally? To answer these questions, we must understand why supersymmetry is broken. However, the mechanism behind supersymmetry breaking is incredibly complex, even for theoretical physicists. Is there a more intuitive way to understand supersymmetry and its breaking?

This problem has confused scientists for a long time. It's as if physicists are climbing a mountain full of branching paths where it's easy to lose one's way. Despite this, we believe that the peak is within reach, and we long to see the view from the top! You can imagine that you are standing on the top of a mountain, the magnificent view would take your breath away. Solving the jigsaw puzzle of physics is just like standing on the summit. You will be amazing at physics is simple and beautiful! The desire to see the beautiful view inspires physicists to keep climbing the mountain, and I am one of them. That is why I want to be a scientist!

Back to the question of how to better understand supersymmetry breaking, one approach lies in condensed matter physics, which studies the properties of many particle systems at low temperatures. In general, to observe some of the less obvious effects, physicists usually give a single particle a huge amount of energy. However, it is mathematically difficult and sometimes our technology cannot afford such a high energy condition. In contrast, when looking at a many-particle system at low temperatures, each particle has low energy. This means that the phenomena are easier to realize and more intuitive. Furthermore, in the world of condensed matter, it is interesting that particles can behave collectively as a group. You can take it as a new 'group particle'. Because it doesn’t exist individually, it obeys to some new rules that are different from those of real particles. This allows physicists to theoretically create a crystal lattice where these 'group particles' condensed together with supersymmetry. Also, we can figure out there exists supersymmetry breaking. It is the charm of condensed matter physics! Although there are still mysteries to unravel, it offers a new way to understand supersymmetry breaking. Undoubtedly, we got a glimpse of the top of the mountain. It is so thrilling!

By understanding the mechanism of supersymmetry breaking in condensed matter systems, we gain insights into how supersymmetry breaks in the universe. The intriguing behavior of 'group particles' under novel rules pushes physicists to rethink what the essence of a 'particle' is. Although the broad impact of supersymmetry is difficult to see in recent years, this work will provide a new aspect to reconsider our existing theories. It could help particle physicists develop a more general theory to describe the phenomenon of supersymmetry breaking, ultimately leading to an epoch-making breakthrough. With all the pieces in place, physicists could complete the jigsaw puzzle using a single elegant equation to explain how our universe works.

Of course, you might think research on supersymmetry is far from our everyday life. However, the beautiful mathematical structure of supersymmetry is a powerful tool for studying other interesting phenomena. By applying it to condensed matter, we can see that condensed matter physics acts as a playground for exploring scientific principles. For instance, when you pour coffee into a cup of milk and let it sit, it eventually becomes a latte. While this may seem simple, there isn't yet a comprehensive mathematical explanation for the process. By replicating this mixing in a crystal, we can again consider the concept of 'group particles.' Here, you could view 'milk' and 'coffee' as two distinct states possessing supersymmetry. As they mix and eventually stabilize, they undergo a transformation that leads to a state without supersymmetry. This transformation is precisely what we call supersymmetry breaking!

In conclusion, studying the properties of supersymmetry in condensed matter physics allows us to uncover more about its breakdown, which is key to understanding the nature of our world. This discovery could not only inspire physicists to devise a perfect equation to describe the universe but also provide us with a fresh perspective to comprehend the phenomena around us.

I use ChatGPT and Grammarly to make my sentences better and revise the grammar.

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[1] 杉野文彦，「量子力学から超対称性へ」，サイエンス社，東京, 2012.

[2] N. Sannomiya and H. Katsura, "Supersymmetry Breaking in Majorana Chains," Phys. Rev. D 99, 045002 (2019).