Supersymmetry – The Universe's "Secret Seasoning"

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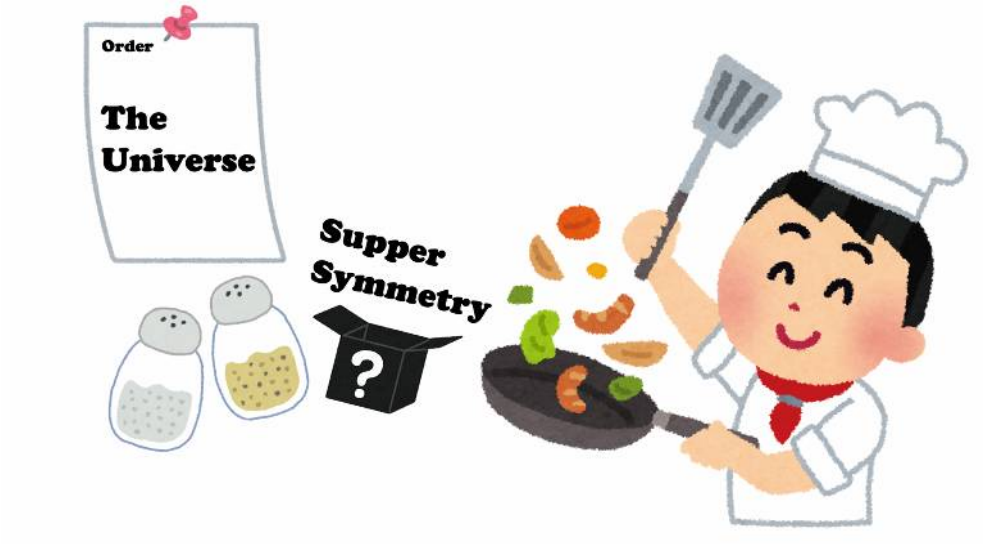

Dear myself at twelve,

Right now—in the year 2025—I'm a graduate student at the University of Tokyo and studying particles. Think of particles as the tiny "ingredients" of the universe. I want to know what ingredients make up the universe and what recipe was used to create it.

1. What's on my plate

You might remember a 2013 news story about the Nobel Prize in Physics. That prize celebrated the discovery of Higgs boson with the gigantic machine called Large Hadron Collider (LHC). Higgs boson was the last missing piece in a theory called Standard Model—the best recipe we have for explaining the universe so far. Standard Model is amazingly accurate. For example, it predicts a special number called muon anomalous magnetic moment. Experiments measure it as 0.00116592 059(22) [1,2,3], and

Standard Model gets almost the same value. Almost. That "almost" still matters. The experiments hint that the real value might differ from the theoretical one in the tiny digits beyond 0.00116592[1]. If that mismatch is real, it means our cosmic recipe is missing a spice.

One theory that could fix the flavor is Supersymmetry (SUSY). SUSY says every known particle has a partner called "super-particle." Add these partners to Standard Model and, in many calculations, the theory can account for the experimental results more precisely, including the muon's magnetic moment.

Actually, no one has seen a super-particle yet. They are thought to be unstable, or almost invisible, hiding cleverly. Finding them is the next big mission for LHC, and that's the experiment I'm working on.

Here's one way to search for supersymmetric particles:
We cook up a "universe" using some recipes—built with computer simulations—and then taste-test it against the real universe. If the supersymmetric recipe reproduces the universe's flavor better than the recipe without supersymmetry, it's strong evidence that super-particles exist.

2. Why I ordered this course

You may wonder why I went down this path. That's because I'm the kind of person who gets excited by the unknown. You may not yet realize that you're that kind of person, but you already know the feeling—the sudden "What's this? I want to know more!" that

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[1] There are differing views on the extent to which the experimental value differs from the theoretical value.

sparks when you meet a bug you've never seen or find a road you've never walked. Were you disappointed to hear that Standard Model still fails to explain the universe fully? I got excited, thinking there are still undiscovered secrets of the universe. You surely will too.

What pulled me into this research was humanity's determination—shown by building the 27-kilometer-long LHC; I was encouraged by the fact that many people gathered from variety of countries constructed an unimaginably huge machine to reveal the secrets of the universe. (The LHC is even listed in the Guinness World Records as the largest machine ever built!) I'm now studying there because I wanted to taste that excitement with them. Uncovering the universe's recipe is super hard, but when I first saw the LHC it felt like a huge, dependable friend who helps us do it. What's more, the LHC will get an upgrade soon, and I'm helping with it—I can't wait to see the upgraded one!

3. How to enjoy your meal

From here on, you will learn many things. You may sometimes feel as if you already know most things. Everything seems to be written somewhere on the Internet, and you might feel lonely, wondering whether any true unknowns are left in the world. Even so, please do not lose your excitement for the unknown. Surprisingly, the world is overflowing with the unknown. If you hold on to that sense of wonder, the world will stay exciting for you. For example, you have probably already heard the word gravity. Perhaps you already know how and from what you feel gravity. However, no one yet

knows how particles feel gravity. The origin of life, the shape of the universe, the dawn of language—there are actually many things that no one knows yet.

Maybe you feel like you've learned so much that it's hard to find things you don't know anymore. Here's one trick for hunting the unknown: doubt what you think you already know. Ask yourself, "Do I really know this?" You might discover you only know a dish's name but have never tasted its flavor. Remember that history-changing ideas like the heliocentric model were born because someone questioned what everyone else "knew"—everyone else only knew that the sun moves in the sky but didn't know why it moves. Do the same, and you'll uncover exciting mysteries of your own.

Follow your curiosity and keep searching for the things you do not yet know. One day, the questions that are unknown to you will become questions that are unknown to everyone. Such puzzles are challenging, captivating, and may become the main dish for you.

<Reference>

[1] Muon g − 2 Collaboration, “Measurement of the Positive Muon Anomalous Magnetic Moment to 0.20 ppm,” Phys. Rev. Lett., vol. 131, p. 161 802, 2023. doi: 10 . 1103 / PhysRevLett.131.161802.
[2] Muon g − 2 Collaboration, “Measurement of the Positive Muon Anomalous Magnetic Moment to 0.46 ppm,” Phys. Rev. Lett., vol. 126, p. 141 801, 2021. doi: 10 . 1103 / PhysRevLett.126.141801.
[3] Muon g −2 Collaboration, “Final report of the E821 muon anomalous magnetic moment measurement at BNL,” Phys. Rev. D, vol. 73, p. 072 003, 2016. doi: 10.1103/PhysRevD. 73.072003.

[4] T. Aoyama et al., “The anomalous magnetic moment of the muon in the Standard Model,” Phys. Rep., vol. 887, p. 1, 2020. doi: 10.1016/j.physrep.2020.07.006.

In the figure, following images are used
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