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メタとメタをつなぐ対話　加藤文元×川上量生×東浩紀「数とはなにか――IUT理論と数学の立ち位置」イベントレポート

ゲンロン編集部

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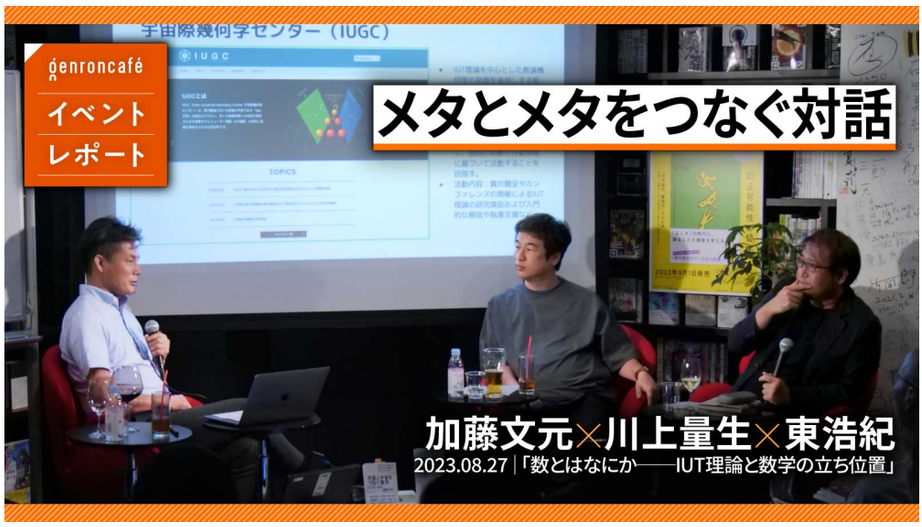

web Genron Delivered on September 19, 2023

previous report

On August 27, 2023, the second public lecture "What is a number? The standing position of IUT theory and mathematics" was held jointly by ZEN University (tentative name) (currently under construction) and Genron. . The speakers were Fumimoto Kato, Masao Kawakami, and Hiroki Higashi.

Prior to its opening, the Inter-Universal Geometry Center (IUGC), a research facility for Inter-Universal Teichmüller Theory, commonly known as "IUT Theory," was established at ZEN University. Kato will serve as the IUGC director. How is

ピックアップ

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Genron Editorial

IUT theory positioned at ZEN University, in the world of mathematics, and in relation to other fields such as philosophy? The conversation between Fumimoto Kato, Michio Kawakami, the instigator of ZEN University, and Hiroki Higashi, the philosopher and founder of Genron, lasted five and a half hours.

Fumimoto Kato x Masao Kawakami x Hiroki Higashi “What is a number? The position of IUT theory and mathematics”
URL= https://shirasu.io/t/genron/c/genron/p/20230827

The event began with the topic of how Fumimoto Kato and Masao Kawakami met. It is said that the person who connected Kawakami and Kato was Toshihiko Nakazawa, a former student of Kato. Mr. Nakazawa worked as a mathematics tutor for Kawakami and then got a job at Dwango. He is currently involved in ZEN University's business.

According to Kawakami, Mr. Nakazawa, who was unemployed at the time and was only doing math, was helping run the math festival ``MATH POWER,'' which Dwango has been holding several times since 2016. Because of this connection, Kato has also appeared on "MATH POWER" several times. The lecture presented at "MATH POWER 2017" was later published as a general commentary on IUT theory, " Mathematics that connects the universe: The impact of IUT theory " (Kadokawa Sophia Bunko, 2023, original book in 2019) Published as.

IUT theory is known as a very difficult theory. Due to its difficulty, it has caused controversy among mathematicians, and it is said that only about 10 people in the world truly understand it. Normally, the IUT theory would be completely incomprehensible to the average person. Nevertheless, the first half of this event was a valuable opportunity to get a glimpse of the fundamental ideas of IUT theory without abandoning the technicalities. In the second half, there was a dialogue between mathematicians and philosophers about what numbers are. We would like to share with you some of the interdisciplinary dialogues between a mathematician, a business executive, and a philosopher.

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Bug report

ABC conjecture and IUT theory

The IUT theory is a mathematical theory proposed by Professor Shinichi Mochizuki of Kyoto University, and it became widely known around the world as a solution to the historically difficult ``ABC conjecture." More than 10 years have already passed since that announcement.

Furthermore, IUT theory is not limited to solving the ABC conjecture; it also uses completely new mathematical ideas and unusual techniques. However, due to its difficulty and rarity, the validity of the theory remains unrecognized in the mathematical community. Kato and Kawakami explain that they founded the IUGC at ZEN University in order to stimulate discussion on IUT theory under these circumstances.

So why were the ABC conjecture and IUT theory so shocking? I would like to briefly introduce the background to the event.

According to Kato, the characteristic of mathematics as a discipline is that it is made up of more than a dozen independent disciplines that are loosely connected. Among them, the ABC conjecture is an argument related to number theory. In mathematics, a ``conjecture" refers to a proposition that is

believed to be true but remains unproven, and a ``proposition" refers to a sentence or formula that is the subject of truth or falsity determination.

So, what kind of unresolved proposition is the ABC conjecture? If this conjecture is solved, a certain kind of ``relationship" between addition and multiplication will become clear. The ABC conjecture can be organized in the following diagram.

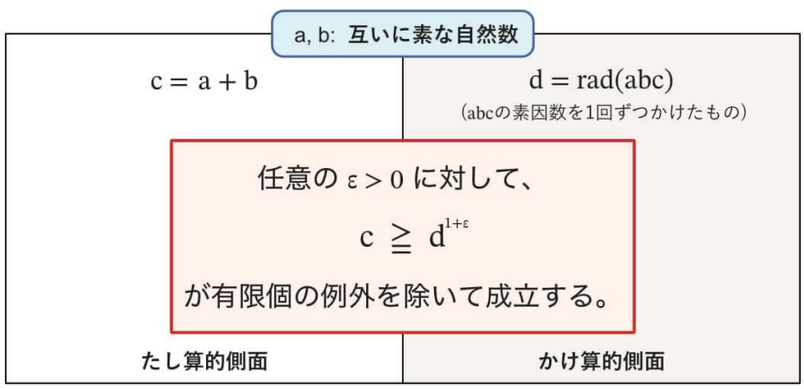

Figure 1 ABC prediction (created by the author from event slides)

The ABC conjecture itself is a combination of addition and multiplication, and its structure is surprisingly simple. Please see the notes at the end of this article for a more detailed explanation, but the predictions can be summarized as follows. For mutually prime natural numbers a and b, c=a+b in the left addition domain and d=rad(abc) in the right multiplication domain, and with a finite number of exceptions, c is larger than d. Holds true [★1] . This is the ABC prediction.

In the ABC conjecture, the relationship between addition and multiplication is complicated. To summarize this conjecture simply, let c be the representative of addition, and then compare the relationship between it and d, which is representative of multiplication. Why is this relationship so difficult? While the addition property is that natural numbers increase sequentially as "1, 2, 3, 4, 5, ...", from this perspective, for example, prime numbers (2, 3, 5, 7, 11, It is difficult to see multiplicative aspects such as the distribution of …). Furthermore, prime factorization, which expresses multiplicative properties, changes in a way that seems ``capricious". In other words, when the different properties of addition and multiplication are mixed together, mathematical

proof becomes extremely difficult.

Kato uses the following metaphor to explain the relationship between addition and multiplication that this conjecture raises. A power of 2 or 3 is a multiplication of a single prime number. However, when you add them up, the multiplication skyscraper collapses. In other words, addition destroys the way multiplication looks. However, the ABC conjecture predicts a certain pattern even within the destruction, so conversely speaking, if it is solved, a new world of mathematics will open up, such as solving other unresolved conjectures. The ABC conjecture is a serious and difficult conjecture that shakes the very basics of mathematics.

At the event, Kato demonstrated an experiment that applied the ABC conjecture to very simple numbers and conditions. According to the experiment, the inequality that appears in the ABC conjecture holds true with about 10% of exceptions. However, does the figure of 10% really fall under the category of "few exceptions"? Kawakami commented, ``Even though it's mathematics, there are some random points," and Higashi commented, ``I understand what the ABC conjecture is about, but I'm more curious about why mathematicians made this conjecture." Ta.

However, this ``ambiguity" is not without some validity. What is important in mathematics is the balance between calculation and intuition. "Intuition" here means deciphering the structure that provides deep insight into the whole of mathematics. Kato explains that the IUT theory was also guided by this intuition.

At this event, a professional explanation was given about the IUT theory, which solves the ABC conjecture and can be extended beyond that. Although the content of the discussion was extremely difficult to understand, the explanations were open to both the general public and mathematics enthusiasts. There was also a lively Q&A session from the audience. Azuma said, ``It really conveys the fundamentals of the idea," and Kawakami said, ``It's something that humans can understand, even though we can't understand it right away." A detailed explanation cannot be given here. Instead, I will post an excerpt from Kato's slide below. Be sure to check out the archived video of the event to see the entire

"passion" that was exchanged there.

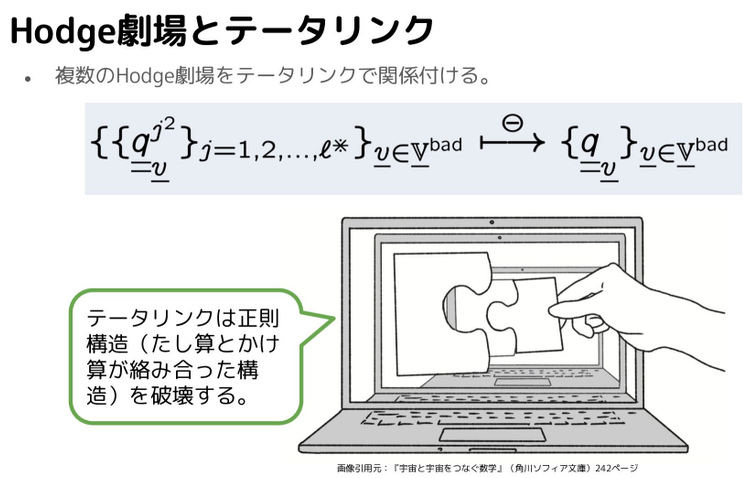

Figure 2 Metaphorical diagram connecting different universes (from slides by Mr. Kato) [★2]

Questions about “reality” through mathematics and philosophy

The excitement that built up in the first half of the event was carried over into a dialogue between mathematics and philosophy in the second half. Kato is a person who has also considered mathematics from a philosophical perspective, as shown in his writings. ? " Azuma, who read Kato's "Riemann's Mathematics and Thought" (Kyoritsu Shuppan, 2017), said that Kato's interest was "What is the reality of mathematical objects?" In other words, the theme of this event, "What are numbers ”.

``Riemann's Mathematics and Thought" is a book that discusses the reality of mathematical objects discovered in the 19th century. According to Higashi, in this work, Kato tried to think of Riemann's mathematical thought in a different way, neither as a calculation of quantities in the empirical world nor as a Kantian transcendentalist cognitive structure. I am introducing this as an attempt. In light of the field of contemporary thought, Kato's point seems similar to the idea of ``speculative realism" advocated by Quentin Meillassoux and others. Unfortunately, however, Riemann is not much talked about in speculative realism. Azuma points out that this may be where Kato's originality lies.

According to Kato, Riemann's mathematics, similar to the IUT theory, was not immediately accepted in the mathematical community after it was announced. The idea of a ``manifold'' called a Riemann surface, proposed around the 1840s, was an important one leading to modern mathematics, but it was not widely accepted until around the 1910s.

Why was the idea of Riemann surfaces not accepted in the mathematical community? In Kato's view, the reason for this was that there was no consensus on epistemology and ontology in the mathematical community. Riemann surfaces cannot be recognized with normal perception. But mathematically it does exist. Such ideas were perceived as dubious.

Azuma points out that there is an important philosophical issue here. Mathematics is generally thought to be built on the basis of things that anyone can understand. For example, the fact that the sum of the interior angles of a triangle is 180 degrees becomes ``self-evident'' in an instant by drawing an auxiliary line.

However, the objects of modern mathematics cannot be grasped using ordinary senses. Therefore, obviousness cannot be easily demonstrated. That's the difficulty.

Taking this into consideration, the controversy surrounding the IUT theory seems to be a condensation of the difficulties in mathematics. The IUT theory may change our very definition of "correctness."

In the second half, discussions surrounding philosophy and mathematics unfolded one after another. There are many issues that were not addressed above. Together with the explanation of the ABC conjecture and IUT theory in the first half, it can be said that this event highlighted the significance of combining philosophy and mathematics to pursue meta-thinking. During the question and answer period, in addition to technical questions, there were also passionate messages from readers who had been reading Kato and Azuma's books for many years. It can be said that it was one of the most "interactive" events at Genron Cafe.

in conclusion

Is the IUT theory "correct"? I don't know. However, in the history of academia, ``really" new and cutting-edge theories are often met with skepticism. Thinking about IUT theory leads to thinking about what mathematics is, what numbers are, and what academics are. This event was a valuable opportunity to engage in dialogue unique to mathematics and philosophy, which explores meta-science and meta-thinking.

Lastly, I would like to touch on the episode that was told at the beginning of this event. ``MATH POWER 2017," where Kato gave a lecture on IUT theory, was made possible by Kawakami's repeated persuasion with Kato. In fact, it seems that Kato even turned down the request immediately at first. However, looking back now, Kato says that it was a turning point in his career as a mathematician, as his lecture was published as a general book on IUT theory and led to the establishment of the IUGC Research Institute at ZEN University.

Mr. Nakazawa, who led Kato and Kawakami to meet and is involved in the ZEN University project, may be a key figure in Japan's mathematics world. Kato and Kawakami said this at the end of the event. These connections between people led to a joint course between ZEN University and Genron. Encounters always

come unexpectedly. We hope that both the audience and those who will lead the future of academia enjoy the unexpected encounter between ZEN University and Genron. (Toshiyuki Aoyama)

★1 The ``relatively prime'' mentioned in the premise of natural numbers a and b refers to a relationship that does not have a common prime factor. Then, consider the relationship between a+b=c, which is expressed by addition, on the one hand, and d=rad (abc), which is expressed by multiplication, on the other hand. Rad is the result of decomposing a natural number n (in this case, the product abc) into prime factors and multiplying each prime number that appears there once, regardless of its order. For example, 8 in rad(8) is multiplied by 2 three times, so we can extract only one 2 and express it as rad(8)=2. In this explanation, ε is omitted, but in this case, with a finite number of exceptions, c is larger than d raised to the power of 1+ε. This is the ABC conjecture.

★2 If I were to express the IUT theory metaphorically, it would be as follows. Addition and multiplication, which are inextricably linked in the world of natural numbers, are separated and treated as independent from each other. We set up multiple stages that connect separate and different mathematical worlds, and communicate between these stages by focusing on the property of symmetry. The distortion caused by the symmetric communication is approximately calculated. Far-Abelian geometry is important in these complex operations. By connecting universes of different mathematics, we can solve the ABC conjecture, which means we can reconsider the relationship between addition and multiplication. IUT theory is not just about solving the ABC conjecture; its scope also extends to the applicability of such complex operations.

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