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Associate Professor Naoki Yamamoto

Theoretical physics to transcend time and space and travel to far off places

"There were times at graduate school when I oscillated between becoming a physicist or choosing another path," Yamamoto tells us. His embarkation on a physics path, his choice of ballroom dance as his club at university, and his experiences amassed as a post-doc overseas, were all a result of an honest adherence to fleeting sensations of "inspiration." Yamamoto's keen sensibilities are now being demonstrated in his education and research activities at Keio University.

Tell me a little about your childhood.

I was born in Shiga Prefecture and raised in Nagoya and Osaka. As the youngest of three brothers, my older brothers definitely helped toughen me up. I remember being made to play soccer, and chasing the ball with all my might.

In junior and senior high school, I was intensely absorbed in mathematics and would solve and enter problem contests I found in magazines as part of my search for challenging problems. The "Homework" column by Péter Frankl in the magazine *Daigaku e no Sugaku* ("Mathematics to University") in particular was replete with difficult problems which one does not learn at senior high school. In my second year of senior high school, I participated in a mathematics seminar chaired by Péter on the University of Tokyo Komaba Campus at which I studied alongside the other participants. My arrival in Tokyo was prompted by my wish to study mathematics at the University of Tokyo.

Why did you go the physics route rather than mathematics which you loved so much?

While my image of physics up until senior high school involved doing calculations using various formulae, at university I encountered quantum mechanics and the theory of relativity. As a result, I learned that physics could facilitate an understanding of the origins of the natural world such as the universe and elementary particles. This is what prompted my switch from mathematics to physics. In fact, as a senior high school student I studied quantum mechanics on my own initiative. Nevertheless, the complex wave function in the Schrödinger equation struck me as confounding that despite the fact that we are not able to measure the wave function itself, this has a tangible bearing on actual physical quantities. During my university classes, I learned about the historical background that led to quantum mechanics, and was able to achieve insights into its significance which had eluded me during my high school days.

I see. So, you chose physics over mathematics because you wished to learn more about the universe and elementary particles?

While I was interested in both space and mathematics as a youngster, I was largely unaware of the best avenues to approach space, and this thus manifested in a vague yearning to become an astronaut. However, when I started university, I learned that physics can be regarded as a means to comprehend the actual phenomena occurring in the universe through logical thinking. This is not limited to the universe as it is today; neither are there limits in terms of distances from our own planet. Consequently, physics can allow us to envisage what the early universe looked like or what is happening in a far distant black hole or during a supernova. The access thus provided to space is of a broader nature than would be possible merely by going there.

I ultimately concluded that, if I am to compete on the world stage, theoretical physics would be the best path for me to make my mark.

What kind of place was your first lab at the University of Tokyo?

Tetsuo Hatsuda was my supervising faculty member while I was at graduate school at the University of Tokyo. He transferred to RIKEN in 2012, and has been researching as part of a new project called iTHEMS (Interdisciplinary Theoretical and Mathematical Sciences Program). He seems to be attempting to clarify various phenomena in physics and biology using mathematics, casting his net wide to recruit personnel and find potential academic solutions. Dr. Hatsuda's interests have been wide-ranging from the get-go, and he is very flexible in incorporating ideas from other fields and applying these to problems in his own field; or conversely, in putting forward his ideas to solve problems in other fields. I think that I am influenced by Dr. Hatsuda in the way in which I think about applying a particular perspective in physics to other fields.

You have also spent time overseas?

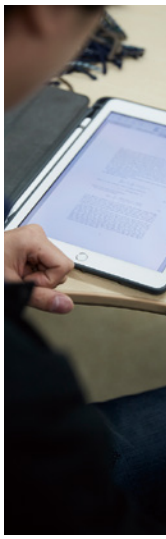
After getting my Ph.D. in March 2010, I made my way to the University of Washington under the JSPS (Japan Society for the Promotion of Science) Postdoctoral Fellows for Research Abroad program, where Dr. Dam Thanh Son, who I admired most at the time, was stationed. Son is a Vietnamese researcher who writes truly elegant papers.

This was the first time that I had read a paper and become convinced that I was in the presence of a work of art. It was as if the scales fell from my eyes. My subsequent thoughts were that I would like to discuss directly and conduct joint research with Son in order to learn what allowed him to produce such a paper.

What do you mean when you say that the paper was elegant?

Firstly, if you look at the results alone the conclusions are far from foregone, and in fact quite surprising. Nevertheless, each step along the path to these conclusions is imbued with an exceedingly simple logic which even a master's student would be capable of following. Then, before you know it, you find yourself at a point extremely remote from the one at which you started.

In theoretical physics, where problems are set up and then tackled, the methodology of setting-up problems is especially important. I learned many things from Son in this regard. Also, the Chiral Transport Theory, which ties in with neutrino transport theory is something I put together in a paper with Son



in 2012.

What kind of place do you find Keio University to be?

I was first appointed to the faculty at Keio in 2014. What surprised me was that the students were extremely friendly, and that they would come to me with questions at the end of the class. They would ask about things that had no relation whatsoever to the class, saying: "Excuse me, but I didn't understand this from a book I read recently..." I was delighted to be approached in this way.

The relationships between the faculty members and the research environment are excellent, and in 2015, we launched the "Topological Science" Project (Strategic Research Foundation Grant-aided Project for Private Universities). This is an outcome of our wishing to get something started with the faculty members of the Physics Department at Yagami Campus and those teaching physics at Hiyoshi Campus. We invite researchers from Japan and overseas who are engaged in interesting research to talk as well as holding international symposiums.

I was selected as a member of the Keio Institute of Pure and Applied Sciences (KiPAS) at the Faculty of Science and Technology from the 2019 academic year, meaning that a research-conducive environment is at my disposal for five years. I am putting more energy than ever before into the problem of supernova explosions. My days are satisfying and productive, both as a faculty member and a researcher.

◎ Some words from students . . . ◎

● Professor Yamamoto is a consistently sympathetic teacher who is also capable of pointed observations on the subject of physics. I took his class when I was an undergraduate student, and the emphasis he placed on the universal aspects of physics as opposed to unravelling a specific problem really resonated with me. I really wanted to debate things with Professor Yamamoto, and so I joined his lab.

His level of intuition when we are discussing and working through calculations and physics principles on the board is truly overwhelming. I believe that it is this thorough knowledge of physics which imparts the insight I need to unravel physics problems.(3rd year doctoral candidate)

(Interview and text writer : Akiko Ikeda)

For the full text of this interview
http://www.st.keio.ac.jp/kyurizukai

The real charm of physics is in finding its universal laws beyond the hierarchies from micro to macro.

Naoki Yamamoto

Specializes in theoretical particle and nuclear physics. 2005, Graduates from the Department of Physics, Faculty of Science, University of Tokyo. 2010, Completes doctoral degree at same university's Graduate School of Science. Ph.D. in Science. Assistant Professor at the Department of Physics, Faculty of Science and Technology, Keio University since 2014, following completion of a post-doc at the University of Washington's Institute for Nuclear Theory, Kyoto University's Yukawa Institute for Theoretical Physics, and the University of Maryland. In his current position since 2017. Concurrent appointment as a KiPAS principal investigator since 2019.