IPMU Interview

with Toshihide Maskawa

Interviewer: Shigeki Sugimoto

My first paper was a Ph.D. thesis

Sugimoto How are you? First I'd like to ask your graduate student days.

Maskawa Well, during those days at Nagoya University, graduate students who were theoretically oriented were not assigned to any particular group. Instead, they went around different theory groups during the first year or so. By the time they were about ready to write their master's theses, they were assigned to the groups of their choice. Anyway, I joined Professor Sakata's group.[1] There I was often teased about behaving as if I were some kind of big shot, even though I hadn't written any papers. (Laughs). Actually, my first paper was my doctoral thesis. Once Yoichi Iwasaki[2] came to Nagoya with the intention of observing us because he thought people from the Nagoya group were standing out and attracting his interest in places like summer school. Unfortunately, we were very busy at that time preparing for things like the Beijing Symposium, a student version of the Japan-China Academic Exchange Program, and for summer school. So, poor Iwasaki had to go back after having hardly any discussion with us. Subsequently, Professor Shoichiro Otsuki[3] gave us a good scolding. He said that he was really ashamed of us, as we had missed the opportunity to talk with a fellow researcher who had come all this way. We had a saying in those days: people living north of Hakone* measured the publications by

Toshihide Maskawa was awarded the 2008 Nobel Prize in Physics jointly with Makoto Kobayashi for "the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature," or, for the "Kobayashi-Maskawa theory" of CP violation. He has also received many other distinguished awards, in particular the 1985 Japan Academy Prize and the 2008 Order of Cultural Merit. He received a Doctorate from Nagoya University in 1967, and became a Research Associate. He moved to Kyoto University in 1970. In 1976, he became an Associate Professor at INS, the University of Tokyo, and in 1980, a Professor at YITP, Kyoto University. He served as Director of YITP from 1997 through 2003. He is now Nagoya University's University Professor and Director General of KMI, Nagoya University. He is also a Professor at Kyoto Sangyo University and a member of its board of trustees.

* Here, "north of Hakone" essentially means Tokyo. On the other hand, "west (or south) of Hakone" includes the Nagoya, Kyoto, and Osaka districts.

weight, rather than by quality.

Sugimoto By weight?

Maskawa Yes, we held that their approach emphasized the quantity rather than the quality of publications, but that we were different. We were aware that we had to write high-quality papers. I had though no publication at all, so there was no quality to discuss. (Laughs)

Sugimoto Have you ever felt that you were at a dead-end or become depressed?

Maskawa No, I'm not the kind of person.

Sugimoto I see.

Encountering a CP violation in a journal club

Maskawa Whenever I encounter a problem, I usually analyze the situation and try to find a solution myself. If something seems beyond my ability, I am willing to switch to an alternative without hesitation. I try to construct a story to describe the hurdle in my path. Of course, the story is not likely to reflect the truth. But I try anyway. However, when things progress and I am beginning to see a breakthrough, this story-building suddenly becomes helpful. For this reason, I guess, we could move rather quickly on the CP problem. We used to have a journal club, when I was at the end of my master's course or at the beginning of my doctorate. Of course, now you can see any paper just by clicking through web pages.

Sugimoto That's right.

Maskawa In those days, however, we had only one copy of each journal for the E-laboratory (the traditional name to represent the elementary particle theory group at Nagoya University). We had to fight over who got it first. So we were having a meeting within the E-laboratory to introduce new articles by taking turns. I was assigned to three or four journals in my first turn. Among them was a paper by Fitch and Cronin on a CP violation. I read it, but at first I did not think it was important and wondered if I should skip it. For some reason, though, I reported the article. I thought something strange was happening but did not have a clear understanding of what it was. Although I did not write a paper, the article motivated me to pursue theories of weak interactions. Many people were working on weak interactions in those days, but they were using them as a probe for studying the quark model rather than actually studying weak interactions. Contrary to these approaches, I became firmly aware of the need to study weak interactions in the framework of renormalizable theory. The famous GIM paper[4] appeared in 1969 (I remember only the year of preprint publication). Later, when Ziro Maki[5] wrote a paper, he mentioned that he had first been informed of the

Shigeki Sugimoto is an IPMU Professor. He is a theoretical physicist. When he was a graduate student at Kyoto University, he joined Professor Maskawa's group.

GIM paper by Maskawa. What intrigued him about this paper was a natural consequence of introducing charm based on higher order effects in weak interactions. But I was more interested in the detailed discussion of how far the theory was renormalizable. That part was given after the charm part using about twice the space.

Sugimoto That is very interesting.

Maskawa Then, the paper by 't Hooft and Veltman[6] appeared in 1971 or 1972. At that time I was working at Kyoto University. Taichiro Kugo[7] recalls that I gathered a group of people and hosted a seminar. Since now 't Hooft had proven the renormalizability of weak interaction theory, I thought it was time to revisit the problem I had left behind earlier. It was time to revisit the CP violation. It was now calculable. I guess what was in the mind of Makoto Kobayashi[8] at that time was the Niu-event,[9] although I never asked him directly.

Sugimoto What is the Niu-event?

Maskawa It was a charm candidate found in cosmic rays, although only one event was found. It was difficult to determine if it was really a charm or not. In those days, it was not at all clear.

Sugimoto I guess people tended to believe it in Nagoya, didn't they?

Maskawa Yes, they did, relatively speaking. I don't think it was either me or Kobayashi who first suggested revisiting the CP violation problem. However, we decided to work together again, as we both happened to be in Kyoto.

Kobayashi-Maskawa theory got gradual recognition

Sugimoto Was the CP violation a big issue in those days?

Maskawa Not really. I guess in 1964, right after the Fitch-Cronin paper had been published, one physicist tried to solve the problem by introducing a 5th force. But it was not very interesting because the postulation of the 5th force that violates CP should have directly solved the problem, if it had existed. Very few people followed this particular idea. At that point we started to investigate this problem and published a paper. But, our paper was almost completely ignored. I'm not entirely sure, but I think it was probably Sheldon Glashow[10] who then wrote a paper without knowing about our work.

Sugimoto I see.

Maskawa However, Yoichi Iwasaki,[2] Hirotaka Sugawara[11] and others acknowledged our work. Iwasaki was familiar with our work since he was working at YITP, Kyoto University. He later moved to Tsukuba University. He informed Sugawara (he was at KEK) about our paper. Sugawara had many friends in the United States. He told them about our work. He even wrote a paper together with Sandip Pakvasa[12] and gave presentations. Sugawara, who was only about two years older than me and lived in the United States for some time, was already a widely respected physicist by then. Thanks to his introduction, our paper became known and gradually began to be cited.

Sugimoto I understand the paper drew very little attention when it first appeared.

Maskawa Ziro Maki was the first to cite our work when he wrote a paper about the 4-quark model. But there were no citations for the next three years or so. Then Pakvasa and Sugawara mentioned our work in their paper.

Sugimoto So your paper became better known after Pakvasa and Sugawara's paper.

Maskawa Yes, the existence of our paper was more widely known after that. Then, at the Tokyo Conference[13] in 1978, Professor Yoichiro Nambu[14] mentioned our work in his summary talk. He compared various CP violation models and concluded that our approach seemed the most appropriate. After the conference, about ten of us, graduates from Nagoya's E-laboratory, went to a beer-garden on the roof of a department store in Shinjuku. They congratulated me with two liters of beer.

Sugimoto Did you have a great sense of accomplishment?

Maskawa Yes. Professor Nambu had virtually certified our work. It was like a declaration of victory.

Sugimoto I see.

Maskawa I didn't remember at all how I managed to return home that night.[15] (Laughs)

Sugimoto Oh, boy! (Laughs) You also pointed out more than one possibility for the CP violation, like the two-Higgs model, in the Kobayashi-Maskawa paper.

Maskawa Let me explain why we did that. I had been curious why the Sakata model[16] did not or could not develop into Gell-Mann's octet-model.[17] But I hardly knew the real reason for it. So I used to ask around. Professor Yoshio Ohnuki[18] told me that he knew how to make an octet out of a three-dimensional representation, but he hesitated to go in that direction because of Professor Sakata's landmark experience. Professor Sakata discussed Heisenberg's paper[19] on nuclear structure theory in his undergraduate dissertation in a very animated way. He noted that the most important thing was the discovery of the neutron. He wrote that people had faced many contradictions prior to that, because they had to explain everything with only protons and electrons. Many problems with nuclear structure quickly went away after the discovery of the neutron. This landmark experience influenced him a great deal. The 1950s was a very confusing era, when particles after particles were

being discovered. He wanted to settle it once and for all by introducing a new concept like Heisenberg had done. Also, for him, that new concept had to be a real particle like Heisenberg's neutron. So he proposed the model of proton, neutron, and lambda. Because of this landmark experience, Professor Sakata could not think of introducing hypothetical quarks. Professor Ohnuki told me that he himself was confined to a similar direction under this environment. So I tried to have a different mindset. Once I find a breakthrough, or even half a breakthrough, I should go back to the starting point once more, rather than sticking to it.

Sugimoto I see. You explore other possibilities.

Maskawa I call this approach "abstraction." When we abstract an approach even if it is half successful, we will see various other possibilities. At the beginning, when we don't know anything, we have to be specific. Otherwise we cannot identify in which direction we need to go. But, once you have identified the direction, you don't need to stick to the Yoshida-route (for climbing Mount Fuji). You can also reach the top using the Gotenba-route. So we wrote down every possibility that we could think of at that time. Here is a mystery that I still do not understand. In our paper I put the six-quark model in the first place. But when I handed over my Japanese draft to Kobayashi, he moved that part to the last place for some reason.

Sugimoto Do you mean the order had been changed?

Maskawa Yes, that part appeared last.

Sugimoto I see. For you, was the most attractive part of the paper the prediction of the existence of six quarks?

Maskawa Yes, that was the most interesting part. However, I have not asked Kobayashi why he changed the order.

Coming up with the six-quark model in the bathtub

Sugimoto I see. By the way, it is by now well known that you came up with the six-quark model in the bathtub.

Maskawa In mathematics we can introduce 100 quarks and develop a general scheme. Since particle physics is a natural science, we cannot talk about something that does not exist, even if it is interesting. In those days, three quarks were known. Also, we knew that four quarks would make an interesting model. So we had a strong inclination to stick to four quarks. But our discussion did not lead to any viable model. At any rate, I thought I could reproduce the CP violation if I introduced, in today's language, right-handed currents. I showed it to Kobayashi. Probably he knew right away it wouldn't work. But as he was cautious, he only said "Let me check at home." The next day he said "No, it wouldn't work. The g_A/g_V ratio does not agree, because the sign comes out wrong." So we threw that idea away. And we went on to struggle within the framework of the four-quark model. In desperation to get away from it, we needed something that could push us to abandon the four-quark scheme. It could have been either of us who first felt that way. I happened to give up first. Perhaps I did not have enough persistence. (Laughs) A place like a bathtub where you are alone is a relatively good place to relax and review an overall scenario, rather than working on specifics. In the bathtub, I was about to give up the whole thing because every direction we had tried had failed to lead to any successful idea. So I was about to decide to write a paper dealing with our failure, even though doing so would put us to shame. I thought I did not want to continue any longer. (Laughs) Then, as I was getting out of the bathtub, an idea came to me, "Wait a minute. We don't need to do it that way – we can write a paper to show that the 6-quark model will work." The reason why I came up with the idea of six was….

Sugimoto You pretty much knew that the six-quark scheme would work, didn't you?

Maskawa Yes, even when we were unaware of the difficulty of the problem, we could probably answer it right away if someone asked the question "What happens if you take six instead of four?" It was merely a matter of playing with numbers.

Sugimoto I see.

Maskawa We started our discussion the next day from ten o'clock, the time Kobayashi would usually show up. I suggested we write a paper with the idea that the six-quark scheme will work, as I had thought the day before. Kobayashi thought for a brief moment and agreed. It was as simple as that.

Sugimoto Were you very excited when you came up with that idea?

Maskawa No, I was not. It may sound ironic, but I felt relieved because at last I could finish it. I did not have a sense of great accomplishment. Rather, it was Yoichi Iwasaki, Hirotaka Sugawara, and Hidezumi Terazawa,[20] all living north of Hakone,* who recognized the importance of the paper! The only thing I felt was that I had come up with a solution to the problem of CP violation that had been bothering me. In Kyoto, however, I used to be teased, with people saying things like "Hey, Dr. Maskawa! Do six quarks really exist?"

Sugimoto Is that so? Subsequently, however, all of them were found one after the other in experiments. How did you feel when that happened?

Maskawa Well, let me see … Some people continue to work on the same subject as if it were their life's work, like "I have finished this, the next

step is this." I am not that type. Once I let it go, I don't feel it to be my work. So, when I was congratulated on the Nobel Prize, I was happy, of course, but it was not like I was jumping for joy. To me, it was more like "Oh, that particular work somehow deserved the prize." (Laughs)

Sugimoto I see.

Maskawa Of course different people feel differently.

Sugimoto Let me ask you about the Nobel Prize. May I ask you for your impression now that things have more or less settled down?

Maskawa Well, I think the whole thing is overly exaggerated in Japan. It is probably not such a big deal in the United States.

Sugimoto I agree.

Maskawa I think it should be enough to say just "Congratulations," if you know a Nobel laureate.

Sugimoto Indeed. Did it change your life in any way?

Maskawa Yes, I am receiving more requests for lectures and interviews. It is partly my fault. My personality makes it difficult to refuse those requests.

Sugimoto You must have become busy!

Maskawa Yes, in that sense. One more thing is I became popular through my appearance on TV, probably because I come across a bit like a comedian.

Sugimoto (Laughs)

Maskawa I am frequently asked to shake hands and give autographs.

Memories of Professor Sakata

Sugimoto I forgot to ask you this earlier. What kind of person was Shoichi Sakata? What memories do you have about him?

Maskawa In those days, he was alternating between his office in Nagoya and the Science Council of Japan in Tokyo weekly. The time he spent in his office of the E-laboratory was when he could relax. So I recall that nearly everything he said was amusing.

Sugimoto Really?

Maskawa In the seminar room, he used to listen to the lecture at first, but after a while he used to start reading the newspaper. When that was done, he used to begin preparing tea. Probably he was sending a signal to stop. (Laughs) One day we had a power failure during the seminar. When that happened, Professor Sakata happened to see the front wall where an electric clock was still running. Someone said "Power failure!" He then said "No, the clock is running."

Sugimoto It must have been a battery-type.

Maskawa Right. He immediately noticed that. He then said, "A power failure means the electromagnetic interaction switches off.** We should say that what we have here is simply a termination of the transportation of power."

Sugimoto (Laughs)

Maskawa Many of his comments were of this sort. But the same Professor Sakata presented impressive lectures on different occasions. His summary at the "Models and Structures" workshop that he organized at YITP was very impressive. I was tempted to say "Why can't you give us such a nice talk in the E-laboratory?" (Laughs) We all listened intensely to his talks whenever they were given at YITP. Probably he was thinking of many different ways to manage the research group; for example, what functions were needed for the group to develop into a good research organization. He had a famous saying in those days, which was that "The best philosophy and best organization are enough for good research. I am just Tadano Bonji." It came from a pre-war comic. A character in the comic named Tadano Bonji (Mr. Ordinary) resembled Professor Sakata. So he got that nickname, which even Professor Shin'ichiro Tomonaga[21] referred to in one of his essays. Professor Sakata did not mind it, and told us, "You young people can do good research here because we have a good philosophy and good organization." I fell for that hook, line, and sinker, and worked very hard. (Laughs)

Sugimoto I don't remember if you told me this directly, but I was told not to call you Maskawa-sensei*** when I first joined your group as a graduate student.

Maskawa That was common in the particle theory community. Ziro Koba,[22] when he was YITP professor, used to say "I didn't teach you anything" whenever people called him Koba-sensei, and he would give no further answer to them. Professor Sakata was worried, I think, that young people might not have the courage to say "no" even if he said something wrong. He probably thought that the organization must have a flat structure to promote discussion as equals. I could sense that, through talking with senior members, though I had never heard that directly.

Sugimoto I see. You had that tradition. Let me ask an odd question. You were calling him Sakata-sensei,*** weren't you?

Maskawa Yes, because he was really my sensei.

Sugimoto (Laughing) But I was not allowed to call you Maskawa-sensei.

Maskawa I could not just call him Sakata-san. To me, Yukawa-san[23] was just Yukawa-san.

Sugimoto Really?

Maskawa Their relationship was rather interesting. When I was a graduate student at Nagoya, I used to visit YITP.

** "Power failure" is written as 停電 in Japanese. 停 means "stop" and 電 means "electric." Usually, 電 is combined with other Chinese character(s) to form a specific word having a meaning related to electric or electronic phenomenon/effect. So, Professor Sakata offered this strained interpretation of 停電 as "stopping electromagnetic interaction."

*** "Sensei (先生)" is a Japanese word meaning "teachers," "professors," and other professionals of authority. For Professor Maskawa, "Sakata-sensei" means not merely "Professor Sakata," but demonstrates his respect for him as a teacher.

A student like me was also asked to join Yukawa at the lunch table. He noticed a short man with an unfamiliar face, and asked me "Whose student are you?" I answered that I came from Professor Sakata's group. We then discussed a few topics. I must have praised Professor Sakata at points in the conversation. He gradually became sullen.

Sugimoto I see. (Laughs)

Maskawa Even at that age, they were competing with each other.

Sugimoto Was it rivalry?

Maskawa Yes, they were rivals. On the other hand, when Professor Yukawa made a one-day visit to Nagoya, Professor Sakata was carrying Yukawa's bag and making way for him at the doors. Sakata was following a strict sensei-student relationship. When I was talking with Professor Sakata, I used to walk slightly behind him. So I did not bother to make way for him at the doors. He opened the doors.

Sugimoto (Laughs)

Maskawa I did not notice it at all. I realized it after I went through the door. (Laughs) In a sense, Professor Sakata had different ways of behaving, one for his superiors and one for younger people. He definitely had different standards—a sort of double standard.

KMI and IPMU: How to start collaboration

Sugimoto Finally, let me ask a question about your new institute (Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, KMI). What direction are you aiming to take?

Maskawa Basically, the universe is its own subject. Koichi Yamawaki[24] made the effort to establish KMI. His standpoint is that elementary particles have a hierarchical structure. He thinks quarks also have structure. He will take the lead and steer the group.

Sugimoto Are you aiming at a new direction that could lead to a Nobel Prize?

Maskawa No, we are not directly aiming in that direction. Some people might deserve a Nobel Prize as a result of their fine accomplishments. I don't believe we should go for it just by shouting a slogan. But, we should always keep in mind that we must try to come up with fundamental solutions. As we have to produce results, sometimes we choose subjects that lead to publication without too much difficulty. I am not against these approaches. They have some importance. But at the same time we should have, in the corner of our mind, an attitude of wanting to answer fundamental questions.

Sugimoto KMI has people from the mathematics department working on subjects close to physics. They may move into directions that are slightly different from describing the real world. How do you plan to proceed as far as collaboration among different disciplines is concerned?

Maskawa I think the first thing is human relations. People just communicate daily, like having a chat after a meal. In doing so, both sides might discover interesting problems. Once that happens, there are many ways to proceed further. People should not confine themselves to their territories. Each person has worked hard in a specific field and accumulated skills and knowledge. If each person draws on those individual strengths, working together with people who have different skills and strengths, I believe they can do great things.

Sugimoto I am now working at IPMU, which has people working on pure mathematics. Collaborative work with them is a major issue. In that sense, IPMU has a similarity with KMI. Do you think there is any possibility for the two institutions to collaborate?

Maskawa We should start with a simple exchange of people, such as inviting people to seminars. People may find some interesting work. We can then try to invite people for longer periods, of six months or a year. Once this exchange is established and our understanding of each other is deeper, we can think of a scheme for more ongoing joint work. I do think we should start personal exchanges, including very simple ones. (Laughs)

Sugimoto Such as having drinks together.

Maskawa Not necessarily, but something like that. (Laughs)

Sugimoto Thank you very much for your time.

1 Shoichi Sakata (1911-1970).
2 Later he served as President, Tsukuba Univ.
3 Professor Emeritus, Kyushu Univ.
4 S.L. Glashow, J. Iliopoulos, and L. Maiani, Physical Review D2 (1970) 1285.
5 Ziro Maki (1929-2005) later served as Director of YITP, Kyoto Univ.
6 G. 't Hooft, Nuclear Physics B33 (1971) 173 and B35 (1971) 167; G. 't Hooft and M. Veltman, Nuclear Physics B44 (1972) 189. 't Hooft and Veltman received 1999 Nobel Prize in Physics.
7 He later served as Director of YITP. Now, Professor, YITP, Kyoto Univ.
8 2008 Nobel Laureate in Physics.
9 An unusual event found in a cosmic-ray experiment in 1971 by Kiyoshi Niu, now Professor Emeritus, Nagoya Univ.
10 1979 Nobel Laureate in Physics.
11 Later he served as Director General, KEK.
12 Professor, Univ. of Hawaii.
13 19th International Conference on High Energy Physics.
14 2008 Nobel Laureate in Physics.
15 At that time, he was working at INS, the Univ. of Tokyo.
16 A composite model of elementary particles proposed by Shoichi Sakata. He postulated that hadrons comprised three fundamental particles: proton (p), neutron (n), and lambda (Λ), and their antiparticles.
17 Murray Gell-Mann proposed classifying hadrons into octets. Later he proposed the quark model with fractionally charged quarks as elementary building blocks. In 1969 he received the Nobel Prize in Physics.
18 Professor Emeritus, Nagoya Univ.
19 Werner Heisenberg (1901-1976). 1932 Nobel Laureate in Physics.
20 A theorist, formerly at INS, the Univ. of Tokyo.
21 Shin'ichiro Tomonaga (1906-1979). 1965 Nobel Laureate in Physics.
22 Ziro Koba (1915-1973) died in Kopenhagen when he was a Professor at the Niels Bohr Institute.
23 Hideki Yukawa (1907-1981). Japan's first Nobel Laureate. In 1949 he received the Nobel Prize in Physics.
24 Deputy Director of KMI and Professor Emeritus, Nagoya Univ.