Interview with Kenji Fukaya

Interviewer: Kyoji Saito

Interaction of Present-Day Geometry with Physics Was a Dream in the 70's

Saito: Today I would like to ask you how you started studying mathematics, how you come up with the geometric structure called the Fukaya categories as well as its past development and its future perspective, and the relation between physics and mathematics. What shall we begin with?

Fukaya: Shall we start from my recent work, because it is related to Kavli IPMU?

Saito: I very much wish to ask you about it. Also, I wish to ask what you think about physics and mathematics. First, could you tell me how you have developed your study of mathematics?

Kenji Fukaya is a permanent member (Professor) at the Simons Center for Geometry and Physics, Stony Brook University since April 2013. He is also a visiting senior scientist of the Kavli IPMU since February, 2013. He graduated from the University of Tokyo (UT) in 1981. He received a Doctorate in Mathematics from UT in 1986. He became Assistant Professor at UT in 1983, and Associate Professor in 1987. He moved to Kyoto University as Professor in 1994. Since 2009, he has been a member of the Japan Academy. He received the Inoue Prize for Science (2002), the Japan Academy Prize (2003), the Asahi Prize (2009), and Fujihara Award (2012).

Fukaya: From the beginning I have been interested in studying various aspects of the relation between mathematics and physics.

Saito: That sounds interesting.

Fukaya: I think that there is a difference between my generation and yours, or, between the mathematics of the time when I started to study and that of the time when you started. According to my impression when I was a student, I always heard that something new would emerge from interactions between physics and mathematics. But, I didn't have an impression at that time that something new really did begin.

Saito: What period was that?

Fukaya: It was probably in the 70's or the 80's when I was a student. Of course, functional analysis emerged and developed simultaneously with quantum mechanics, and the study of partial differential equations has been always connected with physics. There are such fields which are closely connected with physics.

Saito: The Schrödinger equation is an example.

Fukaya: Yes. Also in

representation theory, the relation between quantum mechanics and group theory has been known for a long time. On the other hand, the higher-dimensional global geometry that I have been studying emerged and developed in the 20th century, and has been hardly applied in physics.

Saito: It really was just as you say.

Fukaya: Not to mention physics, it has hardly been used in any fields.

Saito: That's true. When we were students, it looked as if Hilbert space for solving the Schrödinger equation and analysis for solving equations in classical mechanics, electromagnetics, and so on were main mathematical fields that had real contacts with physics. It is only a very recent trend that global geometry, or complex geometry and algebraic geometry, in particular, have come into contact with physics.

Fukaya: Exactly. But, I think the extent to which they obtain citizenship in physics is not clear yet. Since around those days, however, there have been a lot of people who told a rumor, or something like a dream, that contemporary geometry would really have contact with physics.

Saito: What are those days? Do you mean the 70's?

Fukaya: Yes. I suppose that there were such dreams. Rather, I should say certainly there were. But, somehow people had an impression that these were nothing but dreams, and that none of them was decent mathematics. So, I kept at a distance from them. It was probably in the 80's through the 90's that I regarded them as developing into the real thing.

Saito: At that time, epoch-making gauge theory by Atiyah and Donaldson and topological field theory emerged.

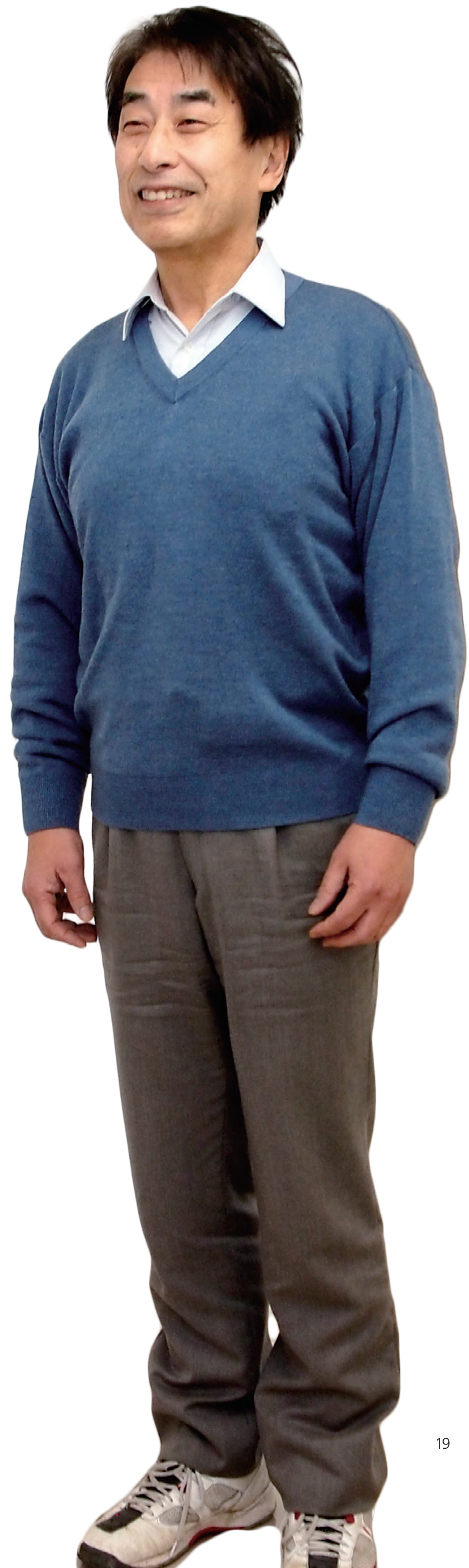
Fukaya: Yes. So, around that time I started to think that now I could work on such things...

Saito: Then, have you been always aware of it?

Fukaya: Yes, I actually wanted to do things like that. When I was a graduate student, however, a prevailing impression was that such subjects were not the sort of things to do.

Saito: That's unexpected! As for me, I was surprised later to know that the theory of primitive forms, which I started with a purely mathematical interest, had to do with physics. But, you have always been conscious of the relation with physics from the beginning, haven't you?

Fukaya: I'm not sure. Even if I have been conscious of it, it was only something like a dream.



Kyoji Saito is Principal Investigator at the Kavli IPMU. He is also Professor Emeritus of the Research Institute for Mathematical Sciences (RIMS), Kyoto University. He served as Director of RIMS from April 1996 to March 1998.

Saito: Could you tell me more about that?

Hoped to See Topology Become a Language for Physics

Fukaya: Probably I hoped to see the times when topology would become a language for physics. I think this has not been achieved yet, but now an atmosphere to make one feel that it may happen, has appeared.
Saito: For instance, V. I. Arnold's Mathematical Methods of Classical Mechanics, though this is not modern. He actively introduced topology to the study of mechanics. Certainly there was already that kind of trend at that time, but isn't it what you are talking about?
Fukaya: Arnold was a pioneer, but he could not establish the application of topology to classical mechanics. For example, *symplectic topology*, which is a field close to what I am studying, was first suggested by Arnold and he developed it by even setting some concrete problems. But it had not been realized until Gromov did it, after all. Not only that, there were pioneers who advocated doing this and that in various fields. Lots of pioneers have always told their dreams. This is not a bad thing, of course, but rather, it is important. Dreams, however, are not enough to develop new fields into the ones which allow normal mathematical studies. It took some more time for symplectic topology, for example, to have become a field allowing normal mathematical studies. When I was young, I felt it a bit scary to go into that field immediately. Rather, I had the impression that it was better to refrain from it.
Saito: Then what was the turning point?
Fukaya: In those days, when Donaldson and other people studied gauge theory in mathematics, they put physics aside a bit when they wrote articles, even though their sources of ideas originated from physics. Though they learned physics, they were strongly conscious that they were not physicists.
Saito: Are you talking about the Atiyah school?
Fukaya: Yes. For example, I think Donaldson never wrote a paper directly dealing with physics. Conversely, physicists later used the Donaldson theory in gauge theory.
Saito: I do not have a clear idea about those circumstances, but am I right to say that although he was not conscious of it, physics played a role behind the scenes for having induced his awareness of the problem?
Fukaya: I think so, probably. In that school, Atiyah had always been strongly aware of the relation between physics and geometry, and the same was true for Hitchin. Therefore, physics had always been behind the mathematics of the Atiyah school at Oxford. Nevertheless, they had not brought physics to the forefront when they wrote articles.
Saito: It was as you say. Then what was your own response?
Fukaya: I think it was from around 1990 that I started to explicitly describe the motivations and ideas that were originated from physics, in my articles. As for geometry, in particular, the relation between gauge theory and topology, that between string theory and duality, and that among homological algebra, physics, geometry, and the like have started from the end of the 80's through the 90's. From around that time, mathematically meaningful results, which directly involve ideas from physics, gradually appeared in geometry.
Saito: Could you give an example?
Fukaya: Mirror symmetry is a typical one. I think mirror symmetry would be a theorem in mathematics, if established, and not a theorem in physics after all. I think such a situation that things like that emerged from physics and became very significant both physically and mathematically did not happen before, say, in the days when gauge theory was developing.
Saito: Gauge theory, which superseded the "gauge theory" in the days of Atiyah, is a treasury full of yet-unknown treasures for mathematics. Putting this aside, mirror symmetry is terribly amazing. The same physical quantity either comes from invariants in complex geometry or from those in symplectic geometry, in mathematics. Admittedly, such a viewpoint has never emerged from mathematics. At what stage did you come to realize this?
Fukaya: I remember that I heard the mirror symmetry for the first time when Professsor Eguchi talked about it at a workshop held at Keio University.
Saito: Around what year?

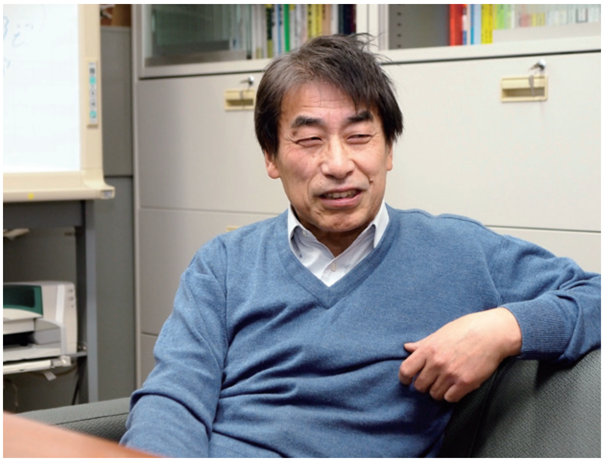
Instinctively Felt D-Brane Is Equivalent to Floer Homology

Fukaya: It was probably the 80' or the early 90's. So it was before the appearance of the Seiberg-Witten theory. At that time, it seemed something like algebraic geometry. Because of that, I didn't think of it as my research subject. It was after I had heard about D-branes that I myself started to study it. I think that I heard about D-branes around 1992 or 1993.
Saito: Yes, I remember that it was around that time.
Fukaya: At that time it came to me that the D-brane is equivalent to Floer homology.
Saito: Was that idea your own?
Fukaya: No, probably many people were aware of it, I think. But few specialists in symplectic geometry were seriously thinking of studying mathematics having to do

with D-brains.
Saito: Had you been working on the Arnold conjecture before that time?
Fukaya: No, it was a bit later. I was involved with Arnold conjecture as an application of Floer homology which I had long been studying.
Saito: I didn't have a clear idea about that situation. How did you relate Floer homology, the Arnold conjecture that we just talked about, D-branes, and mirror symmetry? And at what stage did these things start to converge to a focal point?
Fukaya: It was a matter of course that Floer homology is applicable to the Arnold conjecture, for this is the reason why Floer homology was introduced. On the other hand, we were able to readily understand that D-branes and Floer homology are related when D-branes appeared. D-branes are the boundary conditions for strings. On the other hand, it is Floer homology that takes into account the same boundary conditions and the same nonlinear Cauchy-Riemann equations. However, few people told such an interpretation that the D-brane is equivalent to Floer homology at that time. It may well be that at that time people did not believe that combining the topology of geometry that goes into an infinite dimensional analysis, with newly emerged D-branes in physics, would produce successful mathematical theory. When we heard D-branes at first, they were presented in the contexts completely different from sort of Floer homology.
Saito: Well, at that time I did not quite understand such a situation, either. Certainly I remember that Professor Eguchi and many other physicists had been talking D-branes, but they gave geometrical image that D-branes are the objects, onto which strings are winding. I remember that I repeatedly asked questions because I couldn't get what that meant.
Fukaya: It took about 10 years since then for us to clearly realize the relation between D-branes and Floer homology. For me, it was not very clear at that time, either, though from the beginning they seemed to be related.
Saito: Oh, indeed.
Fukaya: The problem, however, was to what extent we would be able to develop rich mathematics based on that relation. It had also taken 10 years before we reached the level where we were able to calculate what could be one of the most important examples, not merely exploratory pilot trials. Probably that was one of the things that I wanted to do.
Saito: From what time, then, did you realize things like that and start collaboration with various people like Hiroshi Ota and Kaoru Ono?
Fukaya: In the first half of the 90's, the situation was the following. Although we were able to do a variety of things in geometry, which utilizes moduli space, we were quite afraid to study it in a general way because its foundation was extremely difficult. However, when I studied the Arnold conjecture with Kaoru Ono, we came to think with confidence that we would be able to build the foundation of mathematics with which we can tackle that problem.
Saito: Was that in the 90's?
Fukaya: Yes it was in the 90's. I studied Arnold conjecture with Ono in 1996. Around the same time, some other people were also developing the method, which is now called *virtual techniques*. When the virtual techniques turned out to be applicable, only little technical difficulties of that sort seemed remaining. Then we had to write detailed articles. It required hard work, but somehow we thought it was manageable. We gradually changed our minds to do it systematically rather than blindly, for the case of pseudo holomorphic curves. For the case of Donaldson invariants in the gauge theory, at first we also started calculating the most important things for finding new revolutionary examples for application. On the other hand, problems such as finding the structure of all of the Donaldson invariants was too difficult at that time, when we did not know the Kronheimer-Mrowka structure theorem, Seiberg-Witten theory, its relation with the monopole equation, and so on. So, at first we had been working hard only on what we could do one way or another. In this way, we managed to derive very significant things, which was a tremendous breakthrough. As for symplectic geometry utilizing pseudo holomorphic curves, it turned out that the virtual techniques allowed us to overcome technical difficulties if we work hard. With this situation, our motivation turned to the directions such as "What is the most significant algebraic structure?" "As a whole, what does it mean?" and so on. From around 1990, such a way of thinking had gradually emerged, and it was realized in about 10 years over the latter half of the 90's to the 21st century.
Saito: So that was the turning point.
Fukaya: Yes.

Preference for Transcendental Aspects in Mathematics

Saito: By the way, I have strong impression that at first your style of doing mathematics inherited that of Gromov who introduced dynamic new ideas to geometry such as approximating manifolds by taking some points on them or collapsing manifolds with Riemannian metrics. I feel some gap between such mathematics and what you said now.



Fukaya: Well, once I told a joke to you about something like that. Yes, I like transcendental matters. In some sense the mathematics that Gromov has been doing is utmost in transcendental mathematics.
Saito: It's great. I also like it.
Fukaya: I believe that among those mathematicians studying geometry of mathematical physics such as symplectic geometry utilizing pseudo holomorphic curves, I am studying its aspects in close proximity of the most transcendental part.
Saito: Really?
Fukaya: I mean, there are many people studying in more algebraic aspects such as the calculations of Gromov-Witten invariants.
Saito: Well, it's true.
Fukaya: Compared to those who are studying in the area where they can rigorously calculate things like Gromov-Witten invariants, we are studying somehow abstract and general…, I think it's kind of like…, analysis…
Saito: Well, it is rather genuine geometry, than analysis.
Fukaya: Right. So, I have an impression that I am studying transcendental aspects. That is something that I have been intending to do, and I have been doing for a long time. I am quite confident in myself on this point.
Saito: That is what I like about your mathematics. People often think that I am studying algebraic aspects, but I am always watching over from where transcendental structures come in. For this reason, I am really attracted to your mathematics because you are always engaged in such aspects.
Fukaya: But as for Riemannian geometry, which I studied at first, extractable algebraic structures are poor. (laughs)
Saito: Oh, you speak harsh words. (laughs)
Fukaya: Although they are poor, we have to work hard. These days, kinds of mathematics such as analytic geometry on metric spaces are increasingly studied and developing well.
Saito: Really?
Fukaya: Yes. I think geometry of just the opposite type to algebraic geometry is developing quite actively.
Saito: Could you give me an example?
Fukaya: For example, the problem of optimal transportation.
Saito: Hmm… I have never heard of it.
Fukaya: It is something like analysis on metric spaces, such as defining the Ricci curvature in this setting. The optimal transportation problem is, for example, "Suppose there is oil around here, and there are consumers and gas stations around there. Then, how can you transport oil in the shortest time?" In short, you are dealing with metric measure spaces. On a metric space which is the so-called Earth, there are two measures. One is the measure at the oil producing district, and the other is the one at the consumption facility. Evaluating the distance between the two is the transportation problem. So, the best way is the connection by a geodesic.
Saito: So what?
Fukaya: So we are just asking "What is the geodesic between the two points on a very wild space, such as the space of metric measure spaces?"
Saito: Do you mean considering the space of all geometries rather than fixing geometry?
Fukaya: Yes. Because we think all the geometries, our object is wild and measures are not necessarily smooth.
Saito: Is it related to Finsler geometry?
Fukaya: Shinichi Ohta as well as other people is studying it. Once I also studied a bit about metric measure spaces in the 80's. Other currently active fields of geometry similar to it include geometric group theory.
Saito: I am also interested in it.
Fukaya: At present, those areas of mathematics dealing with objects which have little structure, if any, are quite hot.
Saito: Are they developing?
Fukaya: Yes, they are.

Hoping to Explore the Root of Geometry of Moduli Structure

Saito: Now, back to the topic of extracting an algebraic structure using the virtual techniques, what perspective do you have about your future mathematics?
Fukaya: Well, some time ago I thought I would go back to what I studied before—namely, studies of transcendental aspects of mathematics. But, because I am already over 50 years old, I probably wouldn't make significant achievements even if I return to that direction. So now I am inclined to think that the current direction is better.
Saito: What do you mean?
Fukaya: I think there are a lot of things to do in developing the methods of constructing algebraic structures from

moduli spaces using the virtual techniques. If we should complete the whole program, it would lead to a significantly large body of theory. I think probably this is what we should do.

Saito: In some sense, you are going to explore the most fundamental aspect of geometry of moduli spaces. It seems quite tough.

Fukaya: As I said before, since 1996 we have been able to deal with theory even if we give it something similar to an algebraic structure, or rather complicated algebraic structure, but to go one step forward, it would be required to extract all the algebraic structures they have.

Saito: What do you mean by algebraic structure?

Fukaya: For example, it was the A-infinity structure that we used. It is like a study of thinking all the numbers that can be extracted from the moduli space, deriving all the structures it has, and then asking "What is this set of all the structures?" and "What symmetry should all these structures have?" Further, because the numbers themselves are not well-defined, we need to consider what kind of algebra controls this ambiguity.

Saito: So you also look at the structures closely.

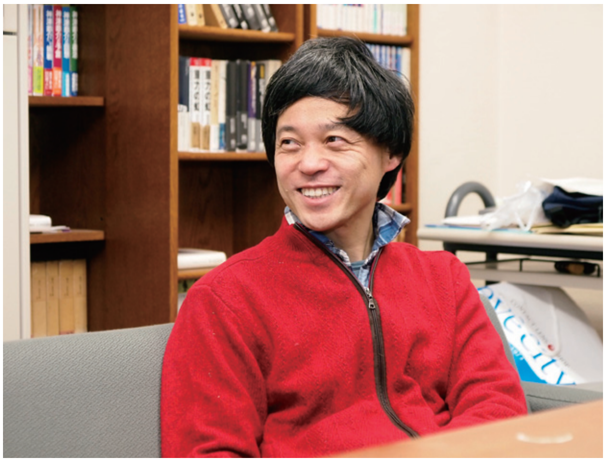
Fukaya: Yes, for the moment. The virtual techniques are sort of tools to construct structures.

Saito: This may be wandering from the topic of this interview a bit, but S. Mochizuki is studying the ABC conjecture these days, and he is trying to extract things from the most primitive part having few additional structures as possible. I think this is amazing...

Fukaya: I agree.

Saito: As you just said, however, you are considering to give structures, aren't you?

Fukaya: For example, let's consider the definition of field theory, or that of a space. There are two ways of thinking. One way of thinking is this. We have lots of quantities from field theory. We define all these quantities and consider their symmetries and in what sense these quantities are well-defined. We consider all these things. In some sense, we can say that it is a computational definition of field theory. Or, probably it is an algebraic definition. It is not transcendental. Now, the other way of thinking is this. It is possible to describe field theory in a truly fundamental way, by creating transcendental, completely different language. The latter is certainly preferable. However, we have been hearing these arguments for about 30 years that new geometry is needed for studying quantum field theory, quantum mechanics, string theory, and so on. But it doesn't seem to be possible at all (laughs). In other words, the latter definition is not possible at all.



Saito: What do you mean by new geometry?

Can a New Geometry Explain the Standard Model Intuitively?

Fukaya: I don't know it very well. As for general relativity, for example, we can say that only one word, *curved space*, explained the geometrical background of gravity pretty well. In the same way, can we explain very complicated equations in the standard model all at once, by developing some new notion of spaces? Is there such an amazing, new type of geometry, of which we simply haven't noticed? Similarly to the fact that general relativity is explained all at once by writing out the definition of Riemannian manifolds, is it possible that writing down the beautiful and simple definition of the new geometry would ultimately lead to the appearance and explanation of everything that are very complicated now, through painstaking calculations starting from that definition? It is probably a dream of hoping such geometry of the 22nd century. I believed in it to a great extent 20 years ago, but now I am skeptical about it, probably because of my age.

Saito: Why do you think so?

Fukaya: In the history of scientific developments, there have been many occasions when a new breakthrough occurred and it made the old things easy to understand. I am skeptical, however, about further and further iterations of such a situation in future. For example, when quantum mechanics and relativity appeared, they looked quite different from our daily life though they were truth. They made things very clearly understandable, however, and they were found not very complicated. This is particularly true for relativity. In the end, it was distilled into a very simple equation. I am doubtful, however, that the so-called standard model etc. would be similarly…

Saito: Are you doubtful that we can generate and formulate a new geometry?

Fukaya: Well, I doubt that the new geometry, even though it is generated, would make everything so easy.

Saito: I can't say it properly, but I think geometry provides humans with a picture when they create an image of the world from various experiences. Speaking about the Riemannian geometry that we have just mentioned, I dare say that Gauss had done huge amount of calculations in electromagnetics and ground survey before it appeared. For instance, it seems that Gauss posed Riemann, one of his students, an assignment to formulate calculations of curvatures from surface triangulation, and Riemann did it. In that sense, though I can't say it properly, it would not change in future that humans necessarily create new geometry corresponding to the amount of experiences they accumulate. So, about what you just said…

Fukaya: There is a distance between our experience and the real world. There is a world where we are living as ordinary people, and which is sensible by our sense organs. In old times, mathematics or any learning was closely connected to the directly sensible world and people directly formulated what they saw into the body of theory. Probably, however, people became unable to do so from a certain stage. I think, this is probably related to abstraction of mathematics: people gradually began to formulate, using logical language, things which were a bit different from what they saw, in such a way that they allowed considering, for instance, curved spaces which looked like Euclidian if seen by human eyes. Then, as we go ahead, we are more and more separated from our intuition.

Saito: Nevertheless, isn't our intuition itself going to change? Don't you think that a new generation of people would take those things into their intuition, which seem logically complicated for us now?

Fukaya: But, there should be a biological limitation for human beings. What you just said means learning by brain. I also think that it would help us to some extent. For instance, mathematicians, having received mathematical training, have intuition that becomes active when they think over mathematics on manifolds. Of course, ordinary people do not have such intuition (laughing). This intuition is what is acquired from learning, rather than what a human being as a creature has by nature.

Saito: I think human beings will take experiences and structures into their intuition.

Fukaya: Well, it may be that we will be able to do it as we go one more step forward, but the required energy will also increase by one step more. You mentioned Dr. Mochizuki before. It is not possible for ordinary people to understand his theory by intuition. Training is needed.

Saito: I agree to some extent, but it depends on the sensitivity of the times. The next generation may be able to reach there, though I cannot.

Fukaya: Well, in the past Grothendieck, for instance, introduced broad perspectives in mathematics. I have managed to understand a bit of them, such as topoi and stacks, through learning, but it is not so easy to understand such things even today.

Saito: Hmm...

Fukaya: About 40 years have passed since then.

Saito: Possibly, at some time in the future they will be integrated into some kind of structure, and people will think the next step without being aware of them...

Fukaya: No, they were constructed in that way with great effort. This is the reason why you find them as you say. But, I think it will not be possible to bring them beyond that.

Saito: We cannot judge unless we try.

Fukaya: Even the definition of manifolds itself is not easy.

Saito: Somehow, I am also doubtful whether it is even natural. But…

Fukaya: We cannot give easier definitions any more.

Saito: Today, 3 years of learning mathematics is somehow enough to understand the definition of manifolds to some extent, though at least a century ago mathematicians at that time were not able to think of it.

Fukaya: Yes, they learn it in the third year at the university. Therefore, it would be in the graduate course that they learn notions of the next level. My concern is the next to next level, and so on. This might be the fate of a human being as a creature.

Ideal Relation between Mathematics and Physics for the Future

Saito: Oh, you are talking about your concern (laughing). I am more optimistic than you. Now let me return to our original topic. What is your perspective on the relation between mathematics and physics in future?

Fukaya: It will be a difficult problem for mathematicians at Kavli IPMU, that to what extent they keep a distance from physicists.

Saito: Do you have any concern about the relation between physics and mathematics? Please don't hesitate to say what you think.

Fukaya: In the study of mathematics, the most dangerous problem would be finding motivation only from physics and giving up mathematics. It is absolutely wrong and should be avoided to say "Though this is not very important in mathematics, it is useful in physics" to mathematicians, and the opposite to physicists. In the fields of mathematics directly related to physics, how to find motivation is important for mathematicians to study mathematics. Every physicist has his/her own sense acquired from training, regarding physical phenomena, or what is really meaningful for physics theory. We mathematicians don't have this sense, and even if we work hard and acquire it to some extent, we are amateurs after all.

Saito: This point is related to our discussion before. Do physicists get their intuition from great amount of calculations they make behind the scene?

Fukaya: I think so. On the other hand, we made another kind of training which formed our sense of mathematical problems and sense of values regarding what is important in mathematics. I think it is quite important to get ideas from physics properly, while retaining our sense of values. So, mathematicians and physicists should firmly keep the respective sense of values, and on the basis of that both should interact with what they can contribute to each other in mind.

Saito: I agree with you on this point. But, is there really a serious concern as you point out?

Fukaya: Yes, I have a feeling to hear such things frequently, though I don't know what physicists are thinking about mathematics. It is sometimes difficult for us to understand physicists' sense of values which are different from ours. Returning to what I've just said, I think the most important physicists' ability that forms their foundations as physicists is to grasp the essence of physical phenomena, or what is the most important in physics. Likewise, mathematicians also have their foundations as mathematicians; they are different from those of physicists. Mathematicians and physicists can understand respective foundations to some extent, but it is difficult and not easy to have both.

Saito: Certainly it is quite difficult to have both...

Fukaya: For example, let's ask if Witten can have both. Simply speaking, it is quite high-level and difficult a thing in the sense that Witten may have both, but only to some extent.

Saito: But, depending on the individual work, do we have to switch between mathematical and physical motivations?

Fukaya: Witten as well as those comparable to him can do that way, because he solved many mathematical problems that are of sufficient value in mathematics. But, even in such cases, their fundamental interests cannot be both physical and mathematical. For mathematicians it is more difficult to acquire sense of physical phenomena. Probably, it's nearly impossible.

Saito: Do you mean it's almost impossible for mathematicians to have intuition on physics?

Fukaya: Yes.

Saito: But if you talk about mathematical phenomena, the situation is different, isn't it?

Fukaya: That's right. So, mathematicians should be conscious about their sense of mathematical phenomena, or awareness of the problems, and to what extent they contribute to understand the most important problem. I have been thinking it is important for mathematicians whether they can properly do so when they go along with physicists.

Saito: Certainly it is a valuable suggestion, or caution, to young people who are about to start learning. I think every established researcher has necessarily chosen one of them in his or her career, but certainly those who are about to begin may not understand it. By the way, you are going to the U.S. to work hard. Do you have any aspiration?

Fukaya: Probably, the Simons Center is in some sense a similar place to Kavli IPMU. Compared to Kavli IPMU, it has slightly bigger mathematics department and similar-sized physics department, but it has no experimental physics department. So I think it is a nice place for me to study what I said.

Saito: Are there physicists?

Fukaya: Yes, at present Michael Douglas is working there. The plan is to have the same number of physicists and mathematicians eventually. The same is true for postdoctoral fellows. I think physicists will be all theoretical physicists. In the Stony Brook University where the Simons Center is located, there is C.N. Yang Institute for Theoretical Physics. Also I think there are experimental physicists in the University. In the Simons Center, I am planning to focus on constructing structures using geometry. I'd like to make a thorough investigation about the extent to which we will be able to reach.

Saito: You are still young, so I have high hopes for you to accomplish another great achievement. Thank you for today.

Note by Saito: On February 20, 2013, I visited Professor Fukaya while he was busy preparing for his departure to the U.S., and I talked with him in his office where his books were piled high. Though usually he speaks very fluently, in this interview it was impressive that he carefully chose his words. It was also impressive that he had been interested in physics from the beginning of his carrier. Does it reflect, as Fukaya said at the beginning, the difference between his generation and mine?