Interview with Motoko Kotani

Jean-Pierre Bourguignon

I am in the Tokyo office of Tôhoku University, one of the Japanese national universities located in Sendai, in the Northern part of the country, to interview Motoko Kotani, a professor at this university and executive vice-president in charge of international strategy for research, for the EMS Magazine.

Jean-Pierre Bourguignon: *Dear Motoko, my first question to you is: when did you decide that you will be a mathematician? Was there a particular person responsible for this decision? Did you have to overcome some obstacles?*

Motoko Kotani: Since I was a very small child, I loved reading books. On the other hand, I was shy and not very good at communicating and participating in social activities with other kids. I enjoyed being by myself with books.

JPB: *Where were you born?*

MK: In Osaka but, when I was 10 years old, my family moved to Kamakura, a suburb of Tokyo. Therefore, I basically grew up in Tokyo. In junior high school, I asked the schoolteachers many questions after classes. The questions were not about what they taught but, since I read books, I came up with some questions and ideas on my own.

JPB: *Questions on mathematics?*

MK: Not necessarily. At the beginning, I went to many teachers, and maybe some teachers considered me difficult. Then I found a mathematics teacher who answered my questions, and I liked to ask him more often. At that time, I thought it was his nature, positive and happy, that made him answer my questions. Now that I have become a mathematician myself and look back, I realize that it's in the nature of mathematics. Indeed, in many subjects, if you are a kid, you probably cannot ask questions in a proper way to a teacher. This involves a lot of knowledge, and also understanding the reason why something being right and wrong is not just logical. But somehow about mathematics I could explain what I thought in a logical way. And the teacher could point out when I made a mistake or I was wrong; or, if I was right, when what he said was actually wrong, I could convince him. I found the whole thing very fair and inspiring, and I became even more motivated. This is how I started to like mathematics.

Professor Motoko Kotani. (Photo credit: Tôhoku University)

JPB: *Was there one specific teacher who really answered more of your questions or were there several?*

MK: There were several ones, that's why I thought it's because of the nature of mathematics. At the beginning, I asked questions related to many different subjects, but eventually I just concentrated on mathematics, because I had good experiences with mathematics teachers, and therefore I continued to ask mathematical questions. At that time, I didn't know mathematician could be a profession.

JPB: *When did you discover there was the profession of a mathematician?*

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MK: Maybe in high school or maybe even when I applied to the university and entered the University of Tokyo. When I discovered there was such a profession, I wanted to become a mathematician.

JPB: *But that you had to study mathematics was obvious to you. It was not physics, not chemistry, not biology?*

MK: Choosing mathematics was obvious. I don't know when I started thinking that way, but I trusted the famous saying that *"mathematics is the language of the universe."* I thought mathematics lies at the core of scientific knowledge. If I had only one life, I wanted to be connected with the most essential language of our universe.

JPB: *When you thought that you may become a mathematician, did that mean immediately that you wanted to get a PhD? Or did this happen after you had gone through graduate school?*

MK: At the University of Tokyo, you first entered the Science School; after two years you had to select your major department. I did very well in my first two years of undergraduate studies, my scores in mathematics and physics were all very good in particular. When I became a student in the mathematics department, I met very talented students, for example, Kenji Fukaya and Mikio Furuta, nowadays well-known mathematicians. I was shocked, and a bit disappointed. It looked like, although I loved mathematics, mathematics did not need me. That was my immediate feeling. Still, I wanted to continue, because I was not able to consider something else as my profession. At the same time, I didn't have the confidence to achieve my goal, namely, to make some kind of contribution in mathematics.

JPB: *Why were you doubtful? Because you had the feeling that other people you were studying with, like Kenji Fukaya or Mikio Furuta, were faster or better than you?*

MK: Faster and much deeper.

JPB: *Oh, you thought so?*

MK: Yes. Completely different dimensions. In the end, I started late, later than them. They were flying in the sky, but I was crawling on the ground. So, they were 3-dimensional, while I was bound to the plane. I developed the feeling that, probably, I cannot contribute too much in my life.

JPB: *Who was your advisor?*

MK: Professor Takushiro Ochiai, an associate professor back then, was my undergraduate advisor. I didn't go to graduate school at the University of Tokyo, but at Tokyo Metropolitan University. There was no professor in differential geometry at the University of Tokyo. Ochiai-sensei said, if I want to continue in geometry, Osaka, Tsukuba and Tokyo Metropolitan are good universities to choose from. I decided to go to Tokyo Metropolitan University because it is in Tokyo, so that I could commute easily.

JPB: *And your advisor for the PhD there was?*

MK: Professor Koichi Ogiue. Actually, he soon after became president of Tokyo Metropolitan University and got extremely busy.

JPB: *That was bad news for you.*

MK: No. I was happy. Anyway, I was quite independent in the studies. When I entered the master course, I had recovered my confidence.

JPB: *Good.*

MK: Because the way undergraduate studies go, you know, there are summits which everybody is aiming at. Since they are beautiful, nothing else seems important. When I started the master course, I found mathematics is actually much richer. There are so many problems you can consider, and, if you are motivated, you can find interesting programmes of your own. I felt there was room for me to contribute.

Actually, I was very quick to write a paper. My first paper [1], which appeared in the Tôhoku Mathematical Journal, was written in the first year of my master studies.

JPB: *And you found a problem to work on by yourself or did somebody ask you questions?*

MK: When I became Oguie-sensei's student, he gave me a list of articles. He suggested me to read the book by Marcel Berger on the spectrum of the Laplacian, and this became my subject. I studied several articles he suggested, and I found some kind of generalization, leading to a paper.

JPB: *In a sense, at some point you really became a mathematician by yourself… when did you defend your PhD?*

MK: It was in 1990.

JPB: *You found that differential geometry was a place where there were enough problems to which you could contribute.*

MK: Geometry used to be more algebraic, the representation of groups or some kind of tensor calculus. When I entered the master course, already global or geometrical analysis was being introduced in Japan. Around Tokyo, Tokyo Metropolitan, Keio, and TiTech, there were several PhD students both in geometry and PDE,

who wanted to learn more about global analysis. We gathered every Saturday to read books, Thierry Aubin's book, and Mikhael Gromov's green book. I found them very interesting. Those topics were more like what I wanted to study. I found differential geometry or global analysis suited me.

JPB: *Was Professor Obata there?*

MK: Professor Obata already retired. This group consisted of younger people, like master and doctoral students. They were all motivated to work in global analysis.

JPB: *Did you have opportunities to travel abroad early in your career? Did any special event, a conference, a visit, a personal encounter play a critical role in the development of your career?*

MK: I don't remember when I went abroad for the first time, but one thing that was very important for me was the International Congress of Mathematicians (ICM) held in Kyoto in 1990. There I met these professors whom I knew only by their names in articles. Before the ICM, there were conferences inviting mathematicians from abroad, specialised in global analysis, geometry, etc. Participating in the ICM was however extraordinary.

JPB: *But you didn't travel abroad before that?*

MK: Actually, I met several people there, and I said I wanted to visit. They invited me, or something like that.

JPB: *What is the first country outside Japan that you visited? Was it the U.S.? Was it Germany?*

MK: Maybe the U.S. I visited David Hoffman.

JPB: *Was he in Massachusetts at that time?*

MK: Yes. And then, in 1993, I applied to visit the Max Planck Institute, and I spent one year in Bonn. During my stay in Bonn, I also visited many other places in Europe. In 2001, I stayed at IHÉS, and École polytechnique in France for one year. These were some opportunities that changed my research scope.

JPB: *At some point in your career, you were asked to take some responsibility, in particular the directorship of a laboratory in materials science. How did this happen? What was the main challenge when you took over this?*

MK: For this, I need to explain from the beginning. The national programme "World Premier International (WPI) Research Centre Initiative" was established in 2007 to build within Japan "globally visible" research centres that boast a very high research standard and outstanding research environment. Applications were open to universities from all around Japan. In the first round, Tôhoku University received one of the five institutes, AIMR, together with the IPMU (University of Tokyo), iCeMS (Kyoto University), IFReC (Osaka University), and MANA (AIST [the National Institute of Advanced Industrial Science and Technology]). And at that time in Japan, there was no support for such big programmes. This one was for the first time a 10-year programme with, each year, 1.30 billion Yen given (close to 10 million Euro), a substantial amount of financial support compared to usual grants. Of course, many research universities wanted to get one. Tôhoku University was very proud to be one of them. Because it was famous for materials science, it was therefore natural that it has the Advanced Institute for Materials Research (AIMR). This programme was very ambitious, with the purpose of reaching world-leading scientific excellence and recognition by not only gathering important persons, who do excellent research, but also by creating a new scientific frontier together through interdisciplinarity and diversity.

JPB: *Then an evaluation came some two to three years after the opening?*

MK: The mid-term evaluation took place in the 5th year, but it was different from the one done by the WPI programme committee which annually monitored the progress made.

JPB: *And the WPI programme committee was external to the lab itself?*

MK: It was an international committee set by the Ministry for Education, Culture, Sports, Science and Technology (MEXT). AIMR has been told the quality of the science was very high but they should have more ambition. The university has excellent researchers in materials science who produce good papers with/without AIMR. The question was: what has been produced which would not have been done without the WPI programme?

JPB: *What should have been the effect of WPI?*

MK: In the application proposal, AIMR promised to create a new materials science by gathering leading materials scientists with different backgrounds from all around the world. When you hear materials science, you may think it is one discipline, but it is not. Materials science is interdisciplinary research, some related with physics, with chemistry, with metallurgy, or with bioengineering. AIMR researchers talked to each other and found several interesting common phenomena across different materials systems, but something more was needed to integrate those ad-hoc discoveries to create a new materials science. You know it is difficult.

JPB: *Okay, so the objective was ambitious.*

MK: As a result, the university found that mathematics could be the catalyst for activating the interaction across disciplines. At that time, I was not involved in the AIMR, but the university noticed that a mathematician led a project called *"Mathematics and Materials Science"* in the CREST programme at the Japan Science and Technology Agency (JST) and thought it could be a solution to invite this person, me, to lead the AIMR to identify its direction.

JPB: *And you became director of the Tôhoku WPI Institute?*

MK: I was invited to become the new director for the centre in 2012, after I went through the mid-term evaluation in 2011 by showing AIMR's strategy, which was accepted well by the WPI programme committee.

JPB: *Wonderful. The main challenge there was to come up with a more ambitious and more global approach. But what was the main challenge you faced when becoming the director, because you were not an obvious choice?*

MK: It took me one month to decide whether I would like to take this position or not when I was invited to become a director by the university. After all, I am not a materials scientist, which is not physics, which is a much more logical subject. It is not such a simple thing to create materials. At that time also, there was some movement in Japan to use mathematics as a basis for interdisciplinary research. I had been claiming that mathematics can play an important role as the common language of science. If you want to really change science, you should use mathematics. I kept saying that. I thought it is an opportunity for me to prove what I have been saying. As a mathematician, I can only say yes when being challenged to prove something.

JPB: *But, in a sense, you didn't feel there was some resistance from physicists…*

MK: I was very lucky that, because of the special nature of the institute, its members were highly motivated for collaboration.

JPB: *Yes, I remember you mentioned to me at that time, that people understood that they had to work together much more closely.*

MK: I was also very lucky that, in 2013, we published a paper in "Science" on materials using topology. A successful example of collaboration with mathematics by conceptualising the data materials scientists obtained in experiments.

JPB: *You with a few people?*

MK: I was one of the authors together with a young mathematician, and several materials scientists doing experiments.

JPB: *Excellent. Later you also became the president of the Mathematical Society of Japan (MSJ). How did this happen? You were the first woman to be in this position.*

MK: It was no less challenging, actually. I had been working in the MSJ Governing Board for eight years by that time. I was happy to contribute to the MSJ in any way.

JPB: *And in this function of MSJ president, what did you find the most challenging?*

MK: What the MSJ faced happened to many academic societies in Japan. The society has a long history: it started at a small scale, based on voluntary effort. It was not built like a company. Many things functioned based on implicit understandings and experiences, without written rules. It was the time academic societies, not only the MSJ, but almost all the society, started reorganising their governance. When I became president, I noticed there were very few written rules. Everything was done in a more or less non-organisational way. As a result, I and several other members of the board decided to establish written legal rules, and this was a real challenge.

JPB: *How long have you been the MSJ president?*

MK: Two years: 2015 and 2016.

JPB: *But at that time, you also were the director of the Advanced Institute for Materials Research at Tôhoku, isn't that right?*

MK: Yes, and I was also a member of the Council on Science and Technology Policy (CSTP) in the Cabinet Office. As a result, I came to Tokyo once a week at least.

JPB: *Could you take care of the Institute, the MSJ and take part in the CSTP at the same time?*

MK: Yes. I used to come to Tokyo frequently. When I came, I stopped by the MSJ office. Actually, it didn't increase my duty so much, but the responsibility was big because, as I said, I tried to reform the MSJ to make it an organisation governed more professionally.

JPB: *Wonderful. The next point I want to make concerns one of the structures at Tôhoku University you have been involved in, namely the* Tôhoku Forum for Creativity*. Was this your idea or somebody else's idea? How did this come about and was there a special need for such a structure at Tôhoku?*

MK: As I told you, I visited the Max Planck Institute in Bonn and IHÉS in Paris. They are institutes where mathematicians can visit and stay

longer under thematic programmes. Japan has such an institute, RIMS in Kyoto, which supports long-time mathematical activities in Japan mainly by organising workshops, and collaborative research among small groups, but does not really run thematic programmes. All mathematicians in Japan wanted to have an institute like MSRI, Institut Henri Poincaré, the Newton Institute. We didn't have one.

JPB: *Oh, I understand. The Tôhoku Forum for Creativity (TFC) runs several thematic programmes annually, but it is not just for mathematics but also open to all branches of science. How was it established?*

MK: I wanted to have such an institute somewhere in Japan. I had the opportunity to speak to the president and executive vice-president for research, and was able to convince them to have it focused on creativity, gathering people from different backgrounds. It was not for the science which already existed, but for exploring pioneering ideas. The president was a big supporter of dreams. In the end, he liked the idea and gave me an opportunity to present this idea to the advisory board of the president, composed in half from industry people, and in half from Tôhoku University people. The CEO of the Tokyo Electron Company, which is one of the biggest semiconductor companies in the world, also liked this idea of buying dreams and decided to finance it. This is why the building has the name Tokyo Electron at the front door. This is how it was built.

JPB: *I understand. As you know, I participated in the TFC Advisory Board, and I really found you managed to attract very good and diverse proposals.*

MK: Thank you. Actually, professor Maeda worked very hard to achieve that. He visited as many researchers at Tôhoku University as he could, discussed with them and encouraged them to apply.

JPB: *You mentioned already at some point that you were involved in the Council for Science and Technology Policy (CSTP) in the Cabinet Office. How was this? Later on, you were also involved in international relations for RIKEN [National Research and Development Agency, Japan] and so on? How did you get involved in all these more policy-oriented actions? Did you propose yourself or did people just call upon you?*

MK: They invited me. I think it is related with my being successful to rebuild the WPI-AIMR. They thought I was good at taking care of different organisations, possibly international ones. I could approach things from several different angles, and that's why they invited me to take these functions.

JPB: *Did the fact that, at that time, Yuko Harayama, a colleague of yours at Tôhoku, was a CSTP executive director play a role?*

MK: I don't know, but I guess it was the case. The structure of the CSTP is the following: the chair is the prime minister himself, half of the members are ministers related to science and technology, and half of the members are so-called executive members, some from industry, some from academia, and one representative from the Science Council of Japan. Yuko Harayama and another person from industry were appointed full-time, other members were part-time. It meant that the two were leading the work; the prime minister and ministers taking advantage of it. The prime minister orders forming opinions or plans of actions on certain issues and this executive group works to come back with recommendations or statements on his requests. Upon that response, CSTP together with the ministers discuss the issues. The prime minister decides to move ahead. And then it becomes public, and it is financed.

JPB: *It seems to be a system which does not involve too many intermediaries. You are talking directly to the prime minister. It's not filtered by many layers.*

MK: It is a valuable feature of the CSTP. The members are given opportunities to speak directly to the prime minister without consulting others.

Now, I'm the science and technology co-advisor to the minister of foreign affairs, but such a system has not yet been established there. We meet the minister from time to time and speak to her-/him directly. There is no mechanism however to authorise and make those conversations have financial consequences. They are recommendations to the minister. I think it is also important for the minister to have advisors to hear opinions in this way which are not intended to the public.

JPB: *Wonderful. Other actions you have been involved in concern the situation of female mathematicians. You were associated, for example, with an exhibit of portraits of female mathematicians created by Sylvie Paycha, which was presented in Tokyo at the Europa House, which is the location of the European Union Embassy. You are also a member of the Committee for Women in Mathematics of the International Mathematical Union (IMU). What is your assessment of the situation of female mathematicians in Japan or more broadly? Do you see progress?*

MK: There is progress, but a very, very slow one. The number of girls studying science at the University of Tokyo is not increasing but decreasing.

JPB: *And the percentage is what? 20%? 30%?*

MK: 20% or something like that at the University of Tokyo. At Tôhoku University it is increasing and now it is 30%.

A photo taken at a meeting of the IMU Committee for Women in Mathematics held at the ICTP in Trieste in 2023.
(Photo credit: International Mathematical Union)

JPB: *I see. Do you have some actions in mind which need to be taken to improve the situation?*

MK: The year 2006 is a memorable year for female scientists. The Japan Gender Equality Bureau at the Cabinet Office was established in 2001 and started setting the Basic 5-year Plans. The first one was 2001–2005, and the second one was from 2006 on. Based on the second one, a budget was allocated to projects to encourage women in science. Tôhoku University got its project supported. I was the project leader: we changed some of the working rules to make them more flexible, established a kindergarten on campus, supported parents to work with young kids by hiring babysitters and research assistants, appointed female PhD students as role models for the younger generations and sent them out to give lectures in high schools. I think we did whatever we could do, but the problem continues. Better than nothing, the numbers are going up, but very slowly. For the gender gap index, Japan is ranked 120th among 165 countries in 2023, it is always the lowest among OECD countries.

JPB: *But is there some national effort with special support, or does each university have to decide of an action on its own?*

MK: There has been a national effort. The problem is related with culture, working styles, education, unconscious bias and many other things.

JPB: *This is continuing, or not so much?*

MK: I think it does. National universities, such as Tokyo, Kyoto and Tôhoku, have their performance evaluated and one of the criteria is the ratio of women among faculty staff and students. The rule is that you are encouraged to hire women in line with the ratio of PhD students. It is of course welcome to hire more women, but you are not forced to hire like 50%, i.e., parity. At Tôhoku University the target of the hiring is that 30% should be women.

JPB: *But do you have your own thoughts on why so few women go to study science in universities? Is it just that families are worried if they go in this direction? What is the cause?*

MK: The reason there are very few girls or women in science is that, first of all, in Japan there are two words – *rikei* and *bunkei*. *Rikei* is natural sciences, engineering, medical sciences, etc. while *bunkei* is social sciences, literature and humanities. And there are big gaps between these two groups in relation with gender: one is for men, the other one for women. At the age of 15 at school, there is, as you know, the OECD PISA test. Japan always gets a very high score in mathematics and science literacy. There is sometimes a small gap between girls and boys, but not too big, and anyway the scores of girls are much higher than the averages. This means that there is not much of a difference at the age of 15, but in Japan it is precisely at that age that students have to choose either *rikei* or *bunkei* as their path. When you decide, you don't know much about science; you just look around: here are the guys, here are the women. If you don't have a high motivation to go into science, you follow the traditional trend…

JPB: *And you end up on the other side. But are there actions taken to change this?*

MK: For example, Tôhoku University encourages high school girls to consider going *to Rikei*. We deliver "science ambassador titles" mostly to female PhD students in science. They go to high schools and tell them [The girls in school] that there are a variety of reasons for being interested in science. Science is broad. Scientists are diverse. The girls don't have to be Marie Curie.

JPB: *But do you hope that some changes are coming up? You mentioned that figures could even be decreasing*

MK: Japan really should change. The universities should change. This new big endowment fund for excellent universities could be one of the driving forces. It's not only the situation of women, but also internationalisation is really slow in Japan.

JPB: *Among students, you mean? For faculty?*

MK: Especially for faculty. In the PhD training, especially in science and engineering, I don't know the figures for all of Japan for sure, but at the University of Tokyo, 2-3% in the undergraduate school, around 25% for the master course, around 35% in the doctor course in 2023.

JPB: *Are the figures for Tôhoku or more globally for Japan?*

MK: The figure for Tôhoku University is similar to that of the University of Tokyo. A big challenge for Japanese research universities is to have more international senior faculty members. In the WPI centres, 30% of the principal investigators, and 40% of researchers are international.

JPB: *Recently, you have been active in the International Science Council (ISC), an organisation which brings together international scientific unions and national academies as its members. Do you feel there is a special need for such structures presently? What is your vision about international cooperation in science in structures like ISC?*

MK: My motivation to participate in international science organisations came from the big earthquake in East Japan in 2011, and then more recently from COVID-19. The challenges humanity faces today are global. They should be considered more at the international level. This was even more evident for COVID-19: first, it started in Asian countries, and we didn't expect it would expand so rapidly to the whole world, and in the end it took three to four years to get it under control worldwide. Many problems humanity (as a whole) faces are closely related to science and technology. I believe that, more than before, science can contribute to solve them, at least contribute to seeking for a solution collaborating with many stakeholders. Not a single country, not a single scientific discipline can tackle them. We need to establish platforms or frameworks to form global views. We must help each other. We must also develop a vision on how to go forward to establish a sustainable inclusive society in the future.

JPB: *But do you feel that the present geopolitical tension in the world makes the need for scientists to be more engaged in this direction more necessary, or do you feel that it has always been like this?*

MK: The present tension makes it much more difficult to collaborate at the international level. I however believe the core value of science is its openness. The freedom and responsibility of scientists should be maintained.

JPB: *I see. My next question is, in your function as executive vice-president for research of Tôhoku University, you have been engaged in preparing the university's application to the new ambitious national Excellence Programme. How do you feel about the most recent developments? Tôhoku's application has been preselected. The previous president was very engaged in supporting the application. Now you have a new president at Tôhoku. Will he be as determined to support a project which would bring a major change in the university organisation?*

MK: Yes, I think so. Japan needs change and reform making it more international. Japan is, somehow, very conservative, and is not willing to change. We need more diversity, which is a driving force of evolution.

JPB: *Under the new president of Tôhoku University, your responsibilities as vice-president have been extended to international relations. You have explained to us why, for you, making Japanese universities more international is a very important step to be taken. Do you really feel this is an urgent action?*

MK: I think so. It is most important for Japanese research to keep its high quality. Recently I learned the change in geographical distribution of research. The number of scientific articles with authors in low- and middle-income countries (LMIC; World Bank classification) grew faster than the number with authors in high-income countries (HIC) since 1993 according to the report by Carlos Henrique de Brito Cruz from Elsevier. Now the governments establish funds for global talent mobilities and encourage researchers and students to collaborate internationally.

JPB: *More things you want to say about any new developments in mathematics?*

MK: Since I was involved in research in materials science, I'm more interested in applied questions, but nowadays I think there is no difference between pure and applied areas. They are more or less integrated. Your ideas, especially in geometry, can find applications.

JPB: *A great thank you for having given so much of your precious time for this interview.*

References

[1] M. Kotani, The first eigenvalue of homogeneous minimal hypersurfaces in a unit sphere $S^{n+1}(1)$. *Tohoku Math. J. (2)* **37**, 523–532 (1985)

After having been a fellow of the Centre national de la recherche scientifique (CNRS, France) for 44 years, Jean-Pierre Bourguignon is emeritus since 2013. He taught at the École polytechnique (1986–2012) and was director of the Institut des Hautes Études Scientifiques (IHÉS, 1994–2013). He was the second president of the European Mathematical Society (1995–1998), and the president of the European Research Council (2014–2019) and for another year by interim. Jean-Pierre Bourguignon is now Nicolaas Kuiper honorary professor at the IHÉS. His field is differential geometry and global analysis at the interface with theoretical physics. He has strong ties to Japan, having made numerous academic visits throughout the country. He also received various honours there.

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