IPMU Interview
with Michael A. Strauss

Interviewer: Masahiro Takada

IPMU Has Grown to Become a Major World Institution in Astronomy

Takada: Thank you so much for helping us with this interview. Let me start with this question. Could you tell me your impressions of IPMU?

Strauss: Oh, IPMU is really a wonderful place. Well, you know very well that it has grown so quickly. I guess 2007 was the beginning?

Takada: Yes you are right, we have existed for four years so far.

Strauss: Just four years and a little bit, and it's already one of the major world institutions, at least in astronomy, and I think also in physics and mathematics. It's just astonishing how quickly it has grown. You all have managed to bring together really top people from all over Japan and all over the world. It's very exciting that you are not just focusing on theoretical astrophysics, but also observational work, and you are bringing together different components of the Japanese observational community to start thinking about these large surveys that we are doing, which is really wonderful. I am really happy to see that.

Takada: I am very glad to hear such nice words about IPMU. Thank you! Okay, let me ask you about a different topic. You have been working on very massive galaxy surveys, and we are now working together on upcoming surveys using the 8.2m Subaru Telescope, that is, the SuMIRe project. Could you explain the SuMIRe project for the readers?

Michael A. Strauss is a Professor at the Department of Astrophysical Sciences, Princeton University. He is former Project Spokesperson and Deputy Project Scientist of the Sloan Digital Sky Survey (SDSS). He received his Ph.D. from the University of California at Berkeley in 1989. He became a faculty member of the Department of Astrophysical Sciences, Princeton University in 1995, and a full professor in 2004.

Excited by the SuMIRe Project

Strauss: Well, the first thing to say is that the Subaru telescope is one of the best telescopes in the world. It's one of the largest optical telescopes in the world, with an 8.2-meter diameter mirror. It's been designed with a very wide field of view, so it's particularly well suited for large-scale surveys both for imaging and spectroscopy. With this in mind, the National Astronomical Observatory of Japan, NAOJ, led by Satoshi Miyazaki, and institutes in Japan including IPMU have built a wide-field imaging camera, called Hyper Suprime-Cam. This is going to be the largest imaging camera on a large telescope in the world, and therefore the most powerful for doing large surveys for covering the sky and mapping the sky to very faint magnitudes to study distant galaxies and faint stars.

So, the first aspect of the SuMIRe project is to image the sky with Hyper Suprime-Cam. We hope to start that survey a little over one year from now. With the images that we gather, we will use gravitational lensing to study the distribution of matter in the universe as a function of redshift, study the properties of galaxies, look for distant quasars, look for structure in the Milky Way halo, and many other things. The data that we will gather will be useful for studying a very large range of different scientific areas.

But in astronomy, to get full information about the physical nature of the objects that we want and in particular to measure the distances of galaxies, we need to measure spectra. We can gain detailed understanding of the physical nature of the galaxies with the spectra. We can measure the chemical composition, surface temperatures and speeds of stars from their spectra. To measure spectra, one needs a different instrument, and that's where the Prime Focus Spectrograph, PFS, comes in. This is the second aspect of SuMIRe. IPMU is playing a leadership role on both of these projects, but in particular, Hitoshi Murayama is the PI of the PFS project and has brought together an international collaboration to design and to build this spectrograph to measure the spectra of objects that we identify from the imaging data. We are starting to design the surveys that we hope to carry out with this spectrograph. We have just spent the last week discussing this topic in a conference with about 80 people in Tokyo. We then continued these discussions here at IPMU discussing the survey plans and how this affects the design of the spectrograph. This project is becoming very real. It's really very exciting. The complementarity of the imaging data and the spectroscopic data together gives you an extremely powerful probe of a huge range of different scientific questions: from cosmology and galaxies to the structure of our own Milky Way.

Takada: Yeah. We can do so many things. However, what is the most exciting and most interesting scientific outcome that you are expecting to get

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from the SuMIRe surveys?

Strauss: Well, we design surveys to do very specific scientific projects. For SuMIRe, the main focus is really two-fold. Understanding the structure of the universe as a whole, probing the parameters of dark matter and dark energy, which dominate the mass-energy density of the universe, that's one goal. The other is to understand the evolution of galaxies. When we look with our telescopes, we see the light from these distant galaxies not as they are now, but as they were in the distant past: because they are so distant, the light takes billions of years to reach us. We can learn about the history of the universe directly from our observations. So, those are the two key goals of SuMIRe.

But, when we do large-scale surveys, we quickly realize that there is lots of other science we can do including scientific areas that we had not anticipated. My experience with the surveys that I have been involved in is that the science that we don't anticipate is often the most exciting. And the way we can make that happen is by doing the highest quality survey we can – we design the survey, the instruments, and of course the telescope, and the survey to do this is focused on the main science goals, but we will try to get the most out of our data that we possibly can and that will enable us to do science that we have not yet anticipated.

Takada: Exactly. You are emphasizing that data quality is really important for getting full potential out of this kind of massive survey.

Strauss: Yes.

Takada: Of course, one aspect of this SuMIRe project, as you mentioned, is international collaboration. Have you found any issues, or any suggestions, for carrying out this size of international collaboration, given your expertise?

Strauss: Well, international collaborations are difficult because, of course, we are separated by such large distances, so we find ourselves having to work very hard on communication, making sure that we actually are communicating with each other and understanding what we are doing. The SuMIRe collaboration involves scientists on four continents; Asia with Japan and Taiwan; North America with the United States; South America with Brazil; and Europe with the French, so trying to work all together is a real challenge. I have been to Japan 11 times in the last four or five years. Most of these times, I have come to visit IPMU, and this sort of intensive travel is what is required. And you have come to visit us at Princeton many times as well.

Takada: So communication is really important for such an international collaboration.

Strauss: Yeah, and having opportunities to be together and work together in the same place. We can communicate by Skype, by phonecon, by Polycom, by email, but being face to face together is still very important, and so we have to spend a lot of time on airplanes. But, it's very exciting. At dinner the other night, we were talking; there was Portuguese, and Spanish, and English, and French, and Japanese, and one of the wonderful things about being a scientist is being part of that international community. I am really enjoying that.

SuMIRe Is a Natural Continuation of SDSS for Massive Galaxy Surveys

Takada: Okay. Again, let me come back to massive galaxy surveys. You have been working on the Sloan Digital Sky Survey for many years, which is the largest galaxy survey thus far. It uses a dedicated 2.5m telescope, and has well controlled data quality. When did you join Sloan Digital Sky Survey?

Strauss: The first time I remember hearing about the project, I was a postdoc at Caltech; this was perhaps 1990. I was observing at Palomar Observatory and Jim Gunn, who was visiting from Princeton, was observing there at the same time. I remember talking to him at that time, and he told me, "You know, I am thinking about this really exciting project and we are going to measure the spectra of a million galaxies." I said, "Oh, my goodness, this sounds very exciting." My thesis work was a redshift survey, spectroscopic survey…

Takada: To measure peculiar velocities of galaxies in the large-scale structure?

Strauss: That's right, peculiar velocities: large scale flows. My thesis included redshifts for about 2,400 galaxies. That took my colleagues and me several years. I spent lots of time at the telescope to measure those redshifts.

Takada: But, he was talking about a million galaxy spectra.

Strauss: He was talking about a million galaxies. I thought, "Oh, this is very, very exciting." In one night with SDSS, we can observe about 5,000 galaxies; twice the size of my thesis every night! I came to Princeton as a postdoc in late 1991. One of the first things I did was to go to Jim Gunn, and I said, "I am very interested in the Digital Sky Survey." It wasn't yet the Sloan Digital Sky Survey because the Sloan Foundation was not yet funding the project. I said, "Is there anything that I could do to be useful?" He said, "Oh, yes, I am sure we can find something you to work on." I started getting more and more involved. I was a postdoc and then I made a transition to being on the faculty…

Takada: Okay. When was that, is that '94 or '95?

Strauss: I became a faculty member in 1995, so I was a postdoc for 4 years.

Takada: At the Institute for Advanced Study?

Strauss: I was at the Institute, that's right. It's separate from Princeton University but very close, as you know; it's not very far away. I was coming to Princeton University quite often. In fact, the Institute was a partner in the SDSS so it was actually officially part of the project. Indeed another person who was at the Institute at the same time as me was David Weinberg who also got involved in SDSS at the same time.

Takada: So you mean you were involved in the Sloan Digital Sky Survey Project from the beginning?

Strauss: Almost, not the absolute beginning… The official beginning of the project was in 1988. There was a meeting held in Chicago to discuss how to make this happen, and Jim was there, as well as people from the University of Chicago. I was not there at that time, only getting involved some years later. The Sloan project, as you know, involves an imaging survey and a spectroscopic survey with the same telescope, so separate instruments for imaging and for spectroscopy. The imaging camera was built by Jim Gunn and his colleagues centered in Princeton, and the spectrographs were built largely by people at Johns Hopkins University, including Alan Uomoto and Steve Smee. The legacy of both of those continues on to the SuMIRe project, both the imaging and spectroscopy. The imaging camera, of course, is built by the Japanese, led by Miyazaki-san. But, Jim and Miyazaki-san have been discussing the design a lot.

The SuMIRe spectrographs are being led again here in Japan, but Jim has been very much involved in the design, and Johns Hopkins, including Steve Smee, is involved as well. With the SDSS, we did wide-field imaging and multi-object spectroscopy, and we were able to characterize the distribution and physical nature of galaxies in the nearby universe at low redshifts, and therefore at the present time. As we ask the next generation of scientific questions, we realize that we need to explore the nature of the Universe as a function of redshift to ask how the distribution of galaxies changes with redshift, and how their physical nature changes with redshift, what the gravitational lensing signature is as a function of redshift.

And all these things require observing much fainter galaxies, and therefore a much larger telescope, which leads us to the SuMIRe project on Subaru. So, it's a very natural continuation of the same scientific themes. In science, we answer many important questions, but new questions come up. For example, when the SDSS started, we had never heard of dark energy. We did not know that the universe's expansion was accelerating. There were a few people who had some crazy ideas that maybe this was happening, no one paid them any attention. Now here we are; it is one of the most important developments in our field in many years.
Now, our view of the universe has changed completely, and we are in this very exciting situation that we have a very complete model for the universe, a very simple model for the universe that describes essentially all the cosmological data we have, with just a very small number of parameters. But, it involves dark energy and dark matter, and we don't know what these things are, so we have a very precise measurement of the things we don't understand, which is a very confusing situation to be in, and it's of course very exciting.

Takada: Yeah I am very interested in the nature of dark matter and dark energy, and believe the SuMIRe surveys can address these very important questions. For the SDSS, how did you deal with such a massive dataset, and how did you prepare the software and pipeline for processing such a huge dataset?

SDSS Almost Failed Several Times

Strauss: Yes, well, when we started SDSS, we had a very poor understanding of how big the software challenge would be. People had reduced images before, so we thought that we could use some of the existing pipelines, and we would develop the software in our spare time. In our first budget, there was no money set aside for software at all, zero. In fact, the software turned out to be one of the most difficult technical challenges of the project. The SDSS had many, many problems. This was one of them. We had a lot of tensions in the early years of the project, a lot of disagreements among people about the writing of the software and how to fix problems with datasets. In addition, we did a very poor job early on of understanding how much it would all cost—so, the original estimation of the cost of the project would be $15 million.

Takada: Fifteen! one-five?

Strauss: Yeah, one-five. The final number was $100 million for the first phase of SDSS. So, we were almost an order of magnitude too small. When I came to Princeton in 1991, I was told that the first light would be in late 1994. First light was in May 1998, so it was 4 years late. We had big money troubles and everything was late. There were many problems. Do you know that there was a book written about the history of the project, by Ann Finkbeiner?

Takada: Yes, I know that. The book about Jim's story describing how the SDSS started. But I haven't yet read it.

Strauss: Yeah, do read it, because it's very interesting. One of the things that we are very aware of in SuMIRe is not to repeat some of those mistakes. We became very realistic about the timescales and the amount of money required. We were talking earlier about international collaborations making sure that communication happens, so we don't spend all of our time fighting, and that's where I think we are doing very well. We don't spend our time fighting; we spend our time working and being productive together and helping each other.

Takada: The SDSS did such a great job. It's really amazing.

Strauss: Yes. Well, it almost failed several times. We ran out of money several times, and had technical problems of all sorts, and organizational problems. Many chapters of Finkbeiner's book describe this. Do you know, for example, that we broke the secondary mirror of our telescope?

Takada: What! I didn't know that.

Strauss: First light of the telescope was in May 1998, and at that point, we were just doing drift-scan imaging on the equator. You don't have to drive the telescope, just keep the telescope fixed and let the sky go by. We were already able to start using those data to do science, and we were starting to write scientific papers 6 months later. But, about a year after that, in 1999, we started doing spectroscopy and the mirror was broken. The secondary mirror is supported on the back by pistons that control focus and tilt. The different pistons push in various ways, and they have to push in a way that's consistent with the shape of the mirror. However, one of the pistons pushed too hard and punched through the glass, putting a hole in the secondary mirror.

Takada: A hole in the secondary mirror!

Strauss: This happened, I think, in November of 1999. I thought at that time, the project is dead; that's the end. But it turned out that the damage to the mirror was confined to the center of the mirror. As you know, the primary mirror has a big hole in the middle so that central part of the secondary is not illuminated, and so it was possible to just patch up the damaged portion, and the secondary was usable after that. That damaged secondary is still there. This is all described in Finkbeiner's book.

SDSS Has Been Making Major Impacts in Many Areas of Astronomy

Takada: Well, once these things were sorted out, you have done some great things with SDSS. Some of the papers using SDSS data have had significant impact on the community and have so many citations, even compared to the papers from the Hubble Space Telescope or the high-energy X-ray satellites.

Strauss: We are very pleased with that. Again, one of the things that's really fun has been that we can make major impacts in many different areas of astronomy from large-scale structure, to distant quasars, to the structure of the Milky Way. Early in the Sloan, one of the things that I was involved in, using some of the very early data, was identifying high redshift quasars. Because of the absorption from the neutral hydrogen in the intergalactic medium, high-redshift quasars are very red. Actually, this was before the SDSS spectrographs were in operation, so we were using the Apache Point 3.5 meter telescope to observe these spectroscopically. I was working with my student Xiaohui Fan (now on the faculty at Arizona). We were observing the reddest objects we could find with the 3.5 meter. We were finding high redshift quasars and very red brown dwarfs at the same time, so half the objects were brown dwarfs and half were high redshift quasars, so we were finding the most distant quasars and the most nearby stars, you know, ten parsecs away and 14 billion light years from us, so it was really lot of fun. That was really exciting observing.

Every night, whenever we found something at very high redshift, we would call Jim Gunn. He told us, "You can always wake me up; if you have a high redshift quasar, wake me up," so we called at two in the morning and said, "Jim, we have redshift 5," and he said, "Oh, that's good, that's good. I am going back to sleep."

Takada: After the big success of SDSS, do you feel that it's easier to work for the new massive galaxy survey, the SuMIRe project, for example compared to mid 90s?

Strauss: Yes, one of the things that we were doing new with SDSS was trying to think about how to work together in large groups. Astronomers—optical astronomers, at least—are used to working in small collaborations, a few people. When we published our first SDSS papers and had over 100 authors, people thought that was really strange. We wrote a detailed policy describing our rules for publications. That turned out to be very important because we needed some way to allow people to follow their scientific interests and to promote the careers of young people and make sure that the best science happened. There are ways to do this wrong and spend all your time arguing about who gets to do what science and who gets to be the first author. By having a clear policy that everyone agreed to, we solved a lot of trouble.

Takada: Yes, for the Hyper SuprimeCam Survey we in the collaboration team agreed to a collaboration policy similar to that of SDSS. Hopefully we can also follow the big scientific success as in the SDSS.

Okay, let's change the topic. For you, what's the difference between theorist, observer and experimentalist in astronomy or cosmology?

Strauss: I have certainly noticed that many people who call themselves theorists in astronomy are finding themselves more and more excited by observational astronomy—in particular survey astronomy because they realize that if they want to test their theories, they need these surveys. Princeton still thinks of itself as a very theoretically-oriented astrophysics department. But, many of the theorists are doing more and more observational work; people like David Spergel, for example.

Takada: Now, no clear boundary. Okay this is the last question. What do you expect for the future of IPMU— any suggestion or comments?

Strauss: IPMU is getting very much involved in and playing a leadership role in these surveys. SuMIRe will keep us busy a long time: we will still be doing SuMIRe science 10 years from now and then we will be thinking about the next wonderful project to do.

Takada: Thank you very much! All you told me and described is very fun and interesting. Please keep working with us on this exciting journey of wide-area galaxy surveys!