IPMU Interview

with George F. Smoot

Interviewer: Naoshi Sugiyama

IPMU is a wonderful place to come and work

Sugiyama: Shall we begin the interview for the IPMU News?

Smoot: Okay, yesterday we posted our first IPMU paper, which I wrote with Damien Easson and Paul Frampton. It is titled "Entropic Accelerating Universe." We are saying that the reason why the universe is accelerating is because of the entropy screen at the horizon, and if you increase the horizon, it makes the entropy increase, so you get an outward force TdS/dr on the horizon. This is just as good as Lambda.

An interesting thing about it is that the first time I went to lunch and met Damien, I then went to tea and met Paul. They were telling me about Verlinde's paper. I said we should have a journal club on it. So I put together an impromptu journal club and we made it through two-thirds of the paper. The next day at tea in Piazza Fujiwara, I said that what we should do is to create a model where we explain dark energy as an emergent force, just as some people try to explain gravity as an emergent force. We should derive dark energy that way. Then Paul said, "We should write a paper right away." So he started writing. I added my section. It's all sort of hand waving but it is my first IPMU paper. It came from lunch and tea together. I image that it is an interesting story for IPMU.

Sugiyama: What is important for IPMU is maximum interaction among people, and this is one of the best examples. How do you find IPMU?

Smoot: I really like IPMU; it's very big and impressive. What's really impressive is how quickly it has grown to international stature. It seems like a wonderful place to come and work and I really like the idea of Piazza Fujiwara.

Also, yesterday I met an

George F. Smoot is Professor of Physics and Director of Berkeley Center for Cosmological Physics at the University of California, Berkeley. He is also Director of Institute for the Early Universe at Ewha Womans University in Korea since December 2008, and Professor of Physics at Université Paris Diderot - Paris 7 since 2010. He was awarded the 2006 Nobel Prize in Physics with John C. Mather for "their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation." Among many other distinguished awards, he received the Albert Einstein Medal in 2003 and Oersted Medal in 2009.

officer from MEXT. I said how IPMU is a good model and how it builds a good foundation. One of the things that I told him I thought was very important was public relations, both to talk to the public and to get their support, but also to encourage young Japanese to become scientists. A couple of days ago I gave a lecture at Kyoto University. After my talk, I had dinner with some of the professors and I was asking them "Why did you become physicists." The first one said, "When I was a young boy, Yukawa got the Nobel Prize." Three of them in a row said the same thing. Almost all of them were influenced very much by the fact that Hideki Yukawa was so valued by Japan. So they dreamed of being similarly valued and that encouraged them to go and do the same.

Sugiyama: So you are the right person to guide young people to cosmology.

Institute for the Early Universe is a partner to IPMU

Smoot: Well, I am encouraging them but I also think there are many other interesting fields. One of the things I spoke about with the MEXT official, who was talking about setting up another WPI, was that the good thing about IPMU is that it is bringing together people from multiple disciplines. When you move into something like energy and climate or synthetic biology, you need people from very different disciplines. IPMU is leading the way in showing how you can put these things together. In Korea, we had the same sort of idea. We have all the researchers and offices on one floor all around the periphery and there is an interaction area in the middle. It's all glass walls, partly frosted. You can write on them like blackboards. So it's a similar idea but on a much smaller scale than IPMU.

Sugiyama: Which fields?

Smoot: That's the Institute for the Early Universe, so it's a partner to IPMU, but a small partner, one-tenth the size of IPMU, with a much smaller budget. We can't offer higher salaries because they are set by the universities. We have 10 faculty, two more positions, and 10 postdoctoral fellows. That is a significant number, but not compared to IPMU. IPMU is clearly bigger and it's clearly more international.

Sugiyama: Are you able to attract people from abroad?

Smoot: There's a lot of encouragement for that. About half of the people are Koreans and half are from overseas. But IPMU is extremely successful and I think part of the reason is that Hitoshi has been very active and part of it is that they actually offer enough money that you can live reasonably. The good thing is that most places can't afford to do that, but the IPMU realizes that it has foreign visitors, and has found nice

Naoshi Sugiyama is a principal investigator of IPMU. He is also Professor of Physics at Graduate School of Science, Nagoya University.

places for accommodation like this one, and has found good subsidies for that. It is attractive for people to come here. It's interesting to be in Japan anyway. Because it's such a big place, and has so many researchers and visitors, it's attractive to come there to meet many people. I've met people from CERN, from the United States, from China and from Japan, many different sets of people. There are a lot of people, and lots of talks. There are so many talks in fact, that I can't go to all of them.

Sugiyama: Right, IPMU has the potential to be an international research hub. That's really important.

Smoot: Yes, it clearly is doing that. Right now it is very strong in theory but Hitoshi is moving to observations with Subaru and Hyper Suprime-Cam. That's the same thing we're trying to do in Korea. We just signed an agreement to be involved in BigBOSS.

Sugiyama: Do you have any advice for IPMU?

Smoot: No, I think IPMU is doing extremely well, and it should encourage overseas researchers to come and visit as much as possible.

Sugiyama: Do you feel that whenever you meet people somewhere else, you can recommend that they visit IPMU?

Smoot: I have encouraged my postdoctoral fellows to come. Three already have, and there are probably another two or three who are going to come this year. And I talked to my colleagues in France. They told me to tell Hitoshi that they would like to build ties from France with IPMU. The French are very interested.

How did the COBE-DMR start?

Sugiyama: So you are impressed with IPMU; that is good news for us. Now let me get into some history. When and how did you start the COBE-DMR (Differential Microwave Radiometers) team?

Smoot: Well, first I was doing early experiments in cosmology, such as looking to see if there was antimatter in the universe, including cosmic ray balloon experiments where we looked for anti-atoms and anti-nuclei. We also did some gamma ray observations. Then I thought of a new way, a better way to do experiments and I went to Luis Alvarez who was overall head of that sort of area. There were four of us postdocs. He said, "Well before you go on to the next experiment, what all of you should do is to consider that your idea is just one of many ideas. You should also look and see what else is possible, what has been discovered, what new technologies are out there, and what new ideas are there because there's something else you can do." And he said, "I recommend you all take a month or two out and study and see what else you might do."

So we did a survey and one of the things we thought about was a Compton Gamma Ray Telescope, which had only just become feasible, and one of the ideas was to try to measure neutrino mass by measuring the end point of the beta decay spectrum, which some people did. The other idea that we came across was using cosmic microwave background (CMB) to see what the large general structure of the universe looked like, not so much the large-scale matter structure but the geometry and temperature of the universe. I thought that would be a really good thing to do. We obtained some seed money and we built a little radio receiver and tested it out on the rooftops and then up on the high mountains and saw where we could do it. Then we said, "Well, we have to fly in the balloon."

Sugiyama: When was this?

Smoot: This was the 70s. Then we had the idea of flying in the U2, which was good because it would bring your equipment right back to you; it didn't crash like the balloon. We couldn't get a lot of balloon flights because there would always be some damage to it, and we had to fix it up to fly again the next season. We flew twice a year if we were lucky; once a year was typical. But we wanted to cover a lot of the sky. With an airplane, we could go repeatedly. We wrote a proposal and eventually got it approved, and we built what's known as a differential microwave radiometer, looking at the two differences. We developed that technology, and then we discovered the dipole anisotropy (which is caused by the Earth's motion relative to the CMB, and is not of cosmological origin) from the U2. We got better limits on the intrinsic CMB anisotropy, but we decided to make a balloon experiment to improve it with a cool version of differential microwave receivers. We needed to move to higher frequency to keep the system compact and, as a result, needed to be higher in the atmosphere to avoid atmospheric fluctuations. We went from 1 cm to 3 mm and we got much tighter limits which was getting to the point where you needed dark matter to make the structure.

But even before the balloon, I put in a proposal to NASA. This was towards the end of the 70s, when there was a big call for proposals for satellites. It turned out that a group from Princeton, MIT and Goddard Space Flight Centre, and then also a group from the Jet Propulsion Laboratory (JPL) put in a proposal. My proposal was to use the DMR to map the sky, the JPL proposal was to use a different kind of fast scanning method to map the sky, and the Goddard, Princeton, and MIT proposal was primarily to measure the absolute temperature; they also had a sky mapping one based on the Princeton experiment. All three of them passed through the first cut, but the JPL and my proposals were for a small satellite while the other one was for a big satellite because it had all sort of stuff in it, and it got merged with IRAS at the time. Then IRAS got into trouble and kicked them off. We made presentations. The outcome, however, was not clear and we were not sure whether they were going to pick us or call for a merger. But it was clear we rated a little more highly than JPL did at the time.

When they kicked the CMB part of the stuff off of IRAS, they said, "Well we will just create a merger and call it COBE and put it behind." So we got put in the queue later. My design won among the presentations, and so I became the principal investigator of the team for anisotropy experiment. And for the spectrum experiment, John Mather's design was the winner. Then one of the other missions kicked off from IRAS was added. Anyway three PIs were designated and formed teams. That's how the whole sequence started, after we had stopped, looked around for an exciting new field, come up with the scheme to make the measurements, built the prototype, learned how to do it, and then put a proposal in that won.

Sugiyama: I see. So do you think the key success of COBE is because of the technology or rather the scientific concepts?

Smoot: I think it was a mix. We had the ideas. I had some people who worked together well and very effectively. This was because I might have an idea for a scientifically good design. You have to say what you are trying to measure and what your primary science goals are. Then you have a set of requirements you get from that, and then you have to make an instrument that fulfils those requirements and can measure them. It was having clarity about what to do and the experience about what to do, and then having people who work together well and effectively.

Exciting science proceeds very quickly

Sugiyama: What did you feel when you found the CMB fluctuations?

Smoot: Well I wrote about it in a book. When we found them so many people wanted to rush and analyze them quickly. We wanted to see what it was. I was crying "No, first we have to keep everybody on the team focused on showing whether this is valid or not, because as soon as you say it's real you quit looking to see if there are any systematic effects." I had to keep everybody thinking "It could be a mistake. Let's check." I didn't want the many people on the team who were doing the hard work of checking the errors to look over and see their colleagues doing data analysis and having fun. I wanted everybody to share equally.

In April 23, 1992, the COBE team announced the discovery of the CMB anisotropy at the annual meeting of the American Physical Society in Washington D.C. We had a series of talks, and when that was done, we held a press conference. Then there was so much press coverage, an unbelievable volume. Hitoshi can tell you about that, because he had just finished graduate school in 1991, and then he came to Berkeley, probably because of COBE.

Sugiyama: Well that's the same for me. I went to Berkeley in 1993, one year after COBE.

Smoot: And then we were going to MAX and MAXIMA to try to look for the first acoustic peak, which is what WMAP was designed to measure very well. But in fact acoustic peaks were scooped well before it, even though it was quickly going on. You have to realize that exciting science proceeds very quickly. It was very amazing, kind of exhilarating around that time, but also very exhausting because we were writing the papers and checking everything and getting it all right.

Sugiyama: But I envy you, because this is kind of like a dream come true.

Smoot: Right, most people didn't really understand what it meant, and in fact if you look at the theoretical papers back then, the idea that you could discover the cosmological parameters from it was really quite new. We were able to learn some things, but it wasn't until a year later, in 1993-1994, that you first started seeing papers saying how you could determine Omega this and that, even though I knew you could do it a little bit from the spectrum.

Sugiyama: This is what we have actually done in Berkeley. One final question: how do you see the future of cosmology? Which direction should we be taking?

Smoot: I think that we have gotten to where we have a good macroscopic understanding of the universe. We have some idea of the general sweep. We are trying to put together all the observations and all of our understandings, and to see if it adds up to the plan as we see it. It requires people who understand astrophysics, people who understand cosmology, people who understand particle physics, and people who know how to do big simulations. You need people who know the different stages of the universe, who know the mathematics, who know the computer stuff, and who know how to interpret the experiments to really test the models and see what's going on. I think IPMU is well positioned for the new stage. IPMU provides the cross-section of people, but you need to be attacking the fundamental problems of cosmology.

Sugiyama: That is a nice conclusion. Thank you.