IPMU Interview

# with Licia Verde

Interviewer: Naoki Yoshida

## Cosmologists can easily move to a new field

**Yoshida:** Welcome to IPMU. It is very nice to have you here.

**Verde:** Thank you very much.

**Yoshida:** First of all, could you give us your overall impression of IPMU?

**Verde:** I think IPMU is very original and it is happening at the right time. There is a confluence of people, who can relate cosmology and astronomy to mathematics and to the more theoretical aspects of physics. It is the right time to start bringing together people from all these different fields and to talk with each other and work together. Actually, that is not easy to do. You need the right environment, you need the right people, and you need the right facilities, because it is not going to happen by itself. But I think these are exactly what you have here at IPMU. I think that the problem is basically building a common language. If you – physicists, mathematicians and astronomers – speak different languages, you are talking about the same thing in different languages, like two roads running parallel. You have to meet at some point. It is a matter of formulating the same problem in a common language, and that is much easier in some fields, say, mathematics and string theories. But for, say, astronomy and particle physics it will take some time. For cosmology it will be much easier. So, cosmology will be the first to make contact.

**Yoshida:** Yes, I think cosmologists have that kind of flexibility. They can easily and happily move to a new field. It might be harder for mathematicians to get used to these languages.

**Verde:** Yes, but I think at least some mathematicians would be very happy to see that there are practical problems to which they can apply whatever work they are doing. Of course it will take a while for them to understand your problem in their language. But once this

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happens, they will be like kids in a candy store.

Yoshida: You have worked at many research institutes, and so perhaps you have some good advice for us. Where did you do your undergraduate study?

Verde: In Padua.

Yoshida: And then you went to Scotland?

Verde: Yes, I went to the University of Edinburgh. In Europe, we have the Erasmus Exchange Programs, and you can do at least one year of your undergraduate degree in a different university with all credits. I liked that a lot, because I really liked the Anglo-Saxon way of going about physics, of thinking about physics. It is more problem-solving rather than the Southern European way, which is, "This is a theorem with a proof and this is a theorem without a proof." With the Anglo-Saxon way, we have a problem and we need to solve it.

Yoshida: That's interesting. I've never thought about in that way, but it is true. And then you did your PhD?

Verde: Yes, I did my PhD in Edinburgh and after that I went to Princeton as a postdoctoral fellow. After that I went to University of Pennsylvania as a member of the faculty and then moved to Spain two years and a half ago.

Yoshida: Returning to the original question, what would you suggest to us, especially given this mix of people working together here?

## Pushing penguins into the water

Verde: It is very hard to say. I think you are heading in the right direction, but I am always aware of the fact that this is Japan, not Italy or Spain. In Italy or Spain, people will be going out of the offices, dragging each other out to talk about football, and then from there they will start to talk about science. It does not work this way here. You can't just take a system that works somewhere else and implant it here. It won't work.

One thing that I think will work here is to start up a reading group. Here people suggest fundamental papers from different fields. These papers must be sufficiently accessible that anybody can understand them and explain them to each other. This must be done in an extremely relaxed setting so that people do not feel ashamed of asking stupid questions at the very beginning like "What is a spectrum?," "Is that really not flat?," or "How do you know that?" This kind of questions should be the norm. But this will probably happen in time anyway.

Yoshida: After spending one and half years here, I feel that we really need to make an effort to do this kind of things continuously. Otherwise it is

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not really going to happen in this way.

Verde: Yes, it is true. So somebody needs to put some effort into that and even to say "I am going to write fewer papers for the next few years, but I can afford to do that," although that is very difficult choice to make because you always want to be marketable. Basically this was set up in Valencia. There, once a week, a group of, say, 15 people from cosmology, astrophysics, and particle physics meet and they choose a subject to discuss. It could be a paper, it could be something; it could be that they invite somebody. But the person who is invited or who presents a paper does not give a talk. This person does have a very small introduction and people have to interact and have to ask questions. There is only a blackboard, no PowerPoint. Sweets and coffee are served and people can come in and out if they want. I found that – and I was really surprised to see it – people start asking the most basic questions and it is even useful if you are talking about your own field. Somebody who is not in your field asks you such a basic question that they really make you think. It is extremely productive. Sometimes you go there to discuss a paper and you do not get beyond the introduction because it is full of questions. But sometimes you come out of the meeting with the outline of two papers. There has been no discussion, but your new paper is basically written right there.

Yoshida: Yes, we should really learn from this.

Verde: That works well. What is very nice is that the symbol they have on the webpage for these meetings is penguins. When you have this big group of penguins and they need to go in the water to look for fish, they are really afraid because there could be seals going after them. So they are all together and they are right on the edge. They hesitate: "Do you go first or should I go first?" It's like pushing yourself a little bit beyond your comfort zone. When the first one goes and nothing happens then everybody will go behind.

Yoshida: It is a lot of fun if we learn only the basics and then we really start understanding this whole new field. I can see that the initial step is really important.

Verde: Yes. When I was at the University of Pennsylvania, I tried to do something like that with string theory group. That was tough at the beginning, but at the end a couple of papers came out. In the work leading to one of these papers, a string theorist, actually started dealing with real data. Now that I moved to Barcelona, I hired a postdoctoral fellow who had worked only in very theoretical stuff. In nine months he was working with me, he started working with data. He was very theoretical, but studied probability and Bayesian statistics, downloaded Supernova data, and started feeding the theories into the data.

Yoshida: So that person is now really an expert in observational cosmology. That's very interesting.

Verde: The big advantage is that cosmology is easy.

Yoshida: Yes, the basic concepts are often very simple. They are also easy to accept or understand.

Verde: Yes. Once your observers have done the very hard job of taking the data, reducing them and giving them to you in a highly digested form, then it is relatively easy to play with them. Of course, there is a ton of work that goes on before that.

Yoshida: OK. I'd like to move on to the next question. How come did you become interested in cosmology?

"I know all these parameters just coming out of my program, nobody else does."

Verde: When I was a small child just learning to read, somebody had the brilliant idea of giving me a book about the sky, instead of a fairy tales book. The book covered everything about the sky: from birds, to the atmosphere, planets, and the universe. I really liked it. All the stuff about the universe sounded interesting. But, at high school I studied the classics, Greek and Latin literature, with relatively little mathematics and science. Nevertheless, I enjoyed some of my mathematics and science classes, although I was not really that good at mathematics.

Yoshida: That's interesting, because I know some of your work is based on complex mathematics.

Verde: At high school I did not realize that mathematics can actually describe the real universe, and so saying that one plus one was two or three did not make any difference to me: they were two abstract quantities. But the moment I realized that mathematics actually describes physics, the difference between one plus one being two or being three became real; something like the bridge staying up or falling down. So when I had to choose university I decided to go into the direction of science. Basically I chose physics because of the career prospects. Physics is broader than astronomy. It is better to choose something that gives you a broad career path.

Yoshida: A reasonable decision.

Verde: So, I chose physics and, well, the first year was a bit of a mess because I did not know what a logarithm was and what an integral was; I didn't know any of these things. But I actually liked it and the path I chose was the direction of doing something more astro-cosmo. Then I went to do my Erasmus Exchange and I really liked the way of viewing physics from the Anglo-Saxon point of view, and I started doing courses related to cosmology. I did my PhD on that, and then I started

applying for jobs.

Yoshida: Eventually you became a WMAP member, to use real data.

Verde: I was at the right place at the right time, and so I had this amazing opportunity. As soon as you start working in such a project, you become very busy. You do not have even time to sleep, because you have deadlines and you want to do things well. But once the results are coming out we are all like, "I know the age of the universe with this precision and nobody else knows it," or "I know all these parameters just coming out of my program, and nobody else does." It was quite amazing. Now an additional issue is that then I could not even go to seminars because people are looking at my face to guess the results.

Yoshida: When was your most memorable moment?

Verde: It is probably the spectrum of microwave background fluctuations. After performing complicated analysis of the data, a beautiful curve comes out and then you realize that "Maybe we were lucky," "Maybe nature was very nice," "Well, maybe it did not have to be that way and the instrument worked amazingly well." After not even a year you have this beautiful spectrum and you have also cosmological parameters, a precision that is unheard of and you realize it is quite impressive.

Yoshida: I remember the first press release in 2003 after the Space Shuttle Columbia accident. You were going to have to wait two weeks.

Verde: We were basically almost ready. I remember we were working hard until very late. Probably that night we were working until 3 or 4 am, and then I went to sleep. "I have to wake up early because we have to finish this, because tomorrow is the day..." Then I remember my husband telling me, "You can stay in bed." What happened was very tragic; and whether our data release was today or tomorrow was no longer relevant.

## Where is cosmology going?

Yoshida: I remember that very clearly. The last question I have is about future of cosmology rather than the future of our universe. Where is cosmology going? Some people say that cosmology is basically done after this precision measurement of basic parameters. How do you feel about that?

Verde: We have some cosmological parameters with extremely high precision, but having these numbers does not mean anything. It is not an actual understanding of the underlying motor, but a framework to work with. It is good that everything seems to fit, but there are still a lot of open questions. We are at the point where the experiments and measurements we can conduct in cosmology can tell us a lot about more fundamental problems: properties or information about inflation, such as whether it really is something like the inflationary paradigm says or something else. We probably need to go beyond simple parameter fitting and we need something like a qualitative step forward, and we are probably going to be struggling for many years to come, especially about dark energy. But who knows? One day somebody might wake up and say, "Okay, now everything is clear." That's the way science works. But you cannot get to that point if you say "Okay, this field is done, now go and find something else." You have to keep banging your head against it.

Yoshida: It sounds like maybe we need even more theoretical work or more ideas rather than measurement itself. What do you think?

Verde: Yes and no. I am wondering what would have happened with the constancy of the speed of light that gave us relativity, if people said "Okay, the speed of light is a constant within 10% or whatever, so forget about it." No, people kept trying to measure it until you get to the point that you say, "I give up. It is a constant." Then, I say "Yes" because simply your theory is not the fundamental one, you need to have a bigger theory that includes the Newtonian one. I do not think you could have arrived at that point if you did not have precision measurement.

Yoshida: Right, interesting. Now you have your new nice institute in Barcelona.

Verde: It is not new, but since we arrived they basically gave us a new corridor and so we are all in the same corridor. People that are more interested in what the institute does – that is, acting as an interface between cosmology, astronomy and particle physics – are all in the same corridor, so in that sense that part is indeed new.

Barcelona is the capital of Catalonia. And I have to say in Catalonia the system works very well. You know that Catalonia is not independent, but it is different, sort of distinct from the central government. They are really proud of not being part of the central government and so they make a point to make things work well. And so you can see that when they do something they put some effort into doing it right. I mean, we're not at that Japanese level by any means, but they put some effort into doing it right, which is good.

Yoshida: Good. Thank you very much for your cooperation.