Interview with Lisa Randall

Interviewer: Shinji Mukohyama

Writing a Book Hoping People Change Their Way of Thinking about Science

Mukohyama: Thank you very much for making time for us. Let me start by congratulating you on the publication of the Japanese translation of your second book.[1] I really enjoyed helping in the translation of your book.

Randall: Thank you for doing that, it's really important, because, as you know, it's a difficult thing. They try very hard, and so it's really good to have a physicist look at it.

Mukohyama: Yeah. I noticed that translating this book took a long time and lot of work. Writing the book really took much more effort.

Randall: Yeah, that's true.

Mukohyama: So how did you find time to do this?

Randall: It is really quite a lot of time. It means giving up other things. I think I don't do all other things as much as I'd like to do. I am often writing when I am traveling —certainly at every available opportunity. Even I remember, I was sitting at the National Academy of Science's meeting, which is a big deal, and Bruno Zumino looked at me and said, "Are you writing your book?" I guess I was just shocked that I was. Basically I try to do whenever I can, but still it ends up taking quite a bit of time, and then I have this chunk of time and you have to do this. Some of it is very enjoyable, but some of it is like a big purpose. To write a book with one idea is not so hard. I think for me it is not that interesting, so I try to put many ideas into the book, and then integrating them into a way that it all makes sense. That becomes challenging. Each chapter was quite a bit, and then figuring out how to

Lisa Randall is Frank B. Baird, Jr. Professor of Science at Harvard University. She received her Ph.D. from Harvard University in 1987. She became Assistant Professor in 1991 and Associate Professor in 1995 at MIT. She held professorships at MIT (1998-2001) and Princeton University (1998-2000) before returning to Harvard University in 2001. She is a member of the National Academy of Sciences (since 2008), European Academy of Sciences and Arts (since 2012), and many other renowned institutes and societies. She was on the list of Time Magazine's "100 Most Influential People" of 2007.

[1] *Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World*, ECCO Press at HarperCollins, September 2011; Random House, September 2011. Japanese translation: 宇宙の扉をノックする, NHK Publishing, Inc., November 2013.

put all the stories together. So, yes, it took quite some time.

Mukohyama: Did you start writing the second book soon after finishing the first one?[2]

Randall: No. In fact, I didn't think I would write a book for a while. I think the original motivation was more about sort of the frustration with the way science was presented, more than just about the physics, which of course I was excited about too; the Large Hadron Collider, Higgs Boson, and all of that. After reading the newspaper, and following the debates, and traveling a bit, it wasn't always clear that even people interested in science understood really how science worked. And I was asked a lot of questions after my first book. So, I realized this could be a very nice book, and then I started writing. But, it was some years later—it was few years at least.

Mukohyama: So do you think the second book changed the way people think about science?

Randall: I think some people get it. I think a lot of people are very stubborn, and so they have their way of thinking. If you don't say what you are thinking, they don't pay attention or they think they know it all. I tried very hard to speak to the middle, so people could talk to each other. Some people appreciate that. But, I think we have a long way to go. I think just in the terms the way things have come out, people in America just like that argument much more, they don't like to find this middle ground as much. But, I pursued it anyway, because I think it's important. I think it will be a little while before things change. But, maybe, it's changing a little bit. I think there was a little bit more attention to thinking scientifically in recent years than there had been before. Maybe it's helping.

Mukohyama: Yeah. We need patience.

Randall: Yeah, I don't know,

[2] *Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions*, Allen Lane at Penguin, June 2005; ECCO Press at Harper Collins, September 2005. Japanese translation: ワープする宇宙 ― 5次元時空の謎を解く―, NHK Publishing, Inc., June 2007.

Shinji Mukohyama is Associate Professor at the Kavli IPMU. He studies theoretical physics and cosmology. He stayed at Harvard University from 2001 to 2004. He supervised the translation of Lisa Randall's first book[2] and the second book[1] into Japanese.

we don't have time. There are too many things that have to be done properly.

Mukohyama: Right. But I hope that the Japanese version of your book and your TV program and so on will change the way people think about science and get more people interested in science. That's what I hope.

Randall: Oh, that would be nice. Thank you. I hope so too.

Excited with the Idea of the Warped Extra Dimension

Mukohyama: Now, let us talk about science. Your theory of the brane world scenario and warped extra dimension[3] is now very famous and is considered as one of the most promising scenarios beyond the standard model. But, I wonder what you thought when you first proposed this model with Raman Sundrum. Were you confident that this model would get a lot of attention?

Randall: I am never confident about that. I thought it was a good idea. We wanted to make sure, because in some sense we were really like, "Why didn't anyone see this before?" But, I think we were pretty excited. I don't know what we thought in terms of who pays attention. In fact, in the beginning I don't think people paid as much attention.

Mukohyama: Oh really?

Randall: People made it seem like it was just another extra dimension modeling. We really had to make that clear. Raman gave a bunch of talks in the beginning. Then I started to give talks, and then I think people started learning. Also, I think right then Mark Wise called it "Randall-Sundrum" in his paper. It was very good for us, because it made it clear it was a different kind of model. Yeah, I think people didn't always appreciate right away that it was—some people did, but I am not sure it was immediately known.

Mukohyama: I see.

Randall: But I think we knew that it was different, and we were quite excited.

Mukohyama: I see. But for other people it was too new probably?

Randall: Yeah, I'm not sure. I don't know. I think maybe also because of duality, people thought maybe it's just something that's already known. I think it took a little while before people appreciated that we had really done something different. I could be wrong, but that was maybe the sense I had. But, we were certainly enthusiastic. It was also a funny thing though, because we were finishing up our paper on anomaly mediation and sequestering.[4]

Mukohyama: Right.

Randall: So, we actually delayed these papers until we were done with that.

Mukohyama: Oh, really?

Randall: We were excited, but we wanted to finish the other things. We also wanted to make sure we understood all aspects, and we also had the infinite extra dimension. So we had three papers that we were thinking about at the same time. They were all very interesting.

Mukohyama: I agree. So, you actually have three different models based on the similar setup. How did you come up with different ideas from the similar setup at almost the same time? It's amazing.

Randall: Well, in some sense the math came up with the ideas, because we were working out the model for the sequestered scenario and for this metric; because there are subtleties, as you know, about how it gets communicated and "Does the modulus[5] carry information?" in the anomaly mediation scenario; because we really wanted to have a scenario where it really worked, where you didn't have the leading order terms. It was a tricky thing. We realized you had to have supersymmetry working on the other brane. But in the process we were working out the geometry, we saw this exponential, which is remarkable for people like us who have thought about the hierarchy problem for years. Of course you think about that. But then, I was starting at the metric and I was confused, because it looked like you could remove one of the branes, which was a very surprising thing.

Mukohyama: Yeah, it's very surprising.

Randall: Certainly, when I told people this, they thought it has to be wrong, because we are not allowed to have an infinite extra dimension and because of theoretical

[3] Brane world is a physical setup in which matter and forces are confined to a surface called brane. Warped spacetime geometry is a spacetime that would be flat except for an overall scaling that varies with the position in a direction. Warped extra dimension is an extra dimension along which the higher-dimensional spacetime geometry is warped.

[4] Anomary mediation is communication of supersymmetry breaking by quantum effects. Sequestering is the physical separation of different elementary particle types in extra dimensions.

[5] A modulus is a scalar field whose potential energy function has continuous families of minima.

reasons, which it avoids in a very subtle way.

Mukohyama: Right. It was almost like a theorem before your work.

Randall: Exactly. People thought it was a theorem, in fact. You're right. It's very subtle the way it avoids it, and so there were a lot of subtleties there that we wanted to make sure we weren't missing something.

Mukohyama: Yeah.

Randall: But it really worked—because the equations gave us the hierarchy, and then equations also pointed out that you could remove a brane. But then it became subtle to figure out what it meant. It wasn't like we set out to do this, but because we were thinking about these big problems, it became clear after a while.

Mukohyama: I see.

Randall: As you know, when you solve for M_{Planck} it's independent of the position of the second brane, roughly speaking. This is an incredibly surprising thing if you've thought about an extra dimension. So, understanding that was what took us to the third paper.

Mukohyama: Yeah, I see. Now people think that your scenario, the Randall-Sundrum scenario can be realized in string theory. I think that the KKLT[6] is kind of the string theory realization of this warped extra dimension. But at some point it was not clear whether this kind of warped extra dimension could be realized in string theory. Actually, I think if I remember correctly, there was a kind of no-go theorem. At that time what was your feeling?

Randall: Well, I think I have said this for a while. Although, there is a lot of interesting work that comes out of string theory, I think there is the tendency to think that you are going to be able to figure it all out from first principles. One of the reasons I think model building is important—in addition to matching experiment—is because it forces people to really think harder.

Mukohyama: Right.

Randall: Is it really true that they've figured everything out already, or could it be that there are some interesting things they're missing? I wasn't very worried, because I thought the likelihood that they had figured out everything that's possible in string theory was kind of low. Also it wasn't the point to derive in string theory. It was a model and we wanted to see. But, I guess I do think that there were many things that could happen en-route from the Planck scale to the TeV scale, and it was unlikely that everyone had worked out all of them.

Mukohyama: I see.

Randall: I mean they would also say that a positive cosmological constant is impossible in string theory before.

Mukohyama: Oh, yes.

Randall: There are many things that I've said to people, but then you have to think harder to see if they can work. In some sense, models are an incentive to push a little harder and see "Are there different ways?" I used to draw this picture with people working from the bottom, doing model building, and people working from the top, and you're trying to find a common ground.

What's Next?

Mukohyama: I see. That's great. After having proposed a possible solution to the hierarchy problem, which is really one of the biggest problems in theoretical physics, what is your next aim in your research? What do you want to solve?

Randall: Right. We don't know if that's right and there were many aspects that we worked out, as you know. But, right now, I am thinking about dark matter, because I think that the combination of cosmological, astrophysical, and particle physics measurements—you certainly need to think about all of them to really pin down what dark matter is. As I'll talk about today, we have a new model of dark matter. I think there were just a lot of ideas in dark matter that have yet to be explored and can make a difference for how people study it. That's one of the things. I also think whether we have one solution to the hierarchy problem. I don't know if it's right. So there are still issues to think about there.

What do you think about these days?

Mukohyama: I am still interested in the cosmological constant problem.

Randall: Yeah.

Mukohyama: We worked together on the cosmological constant problem. We have some model and it addresses some important aspects, but...

Randall: It's not a perfect...

[6] S. Kachru, R. Kallosh, A. Linde, and P. Trivedi, *Physical Review* D **68** (2003) 046005

Mukohyama: It's not the real solution.
Randall: Right.
Mukohyama: I want to pursue this direction, but at the same time...
Randall: What other directions do you have?
Mukohyama: I am not sure at this moment; it's kind of a longstanding purpose of my research to attack the problem of the cosmological constant. At this moment I am now interested in dark energy.
Randall: Which is similar, yeah.
Mukohyama: Right. They are related to each other. In the end, we have to solve the cosmological constant problem, and then attack the dark energy problem.
Randall: Maybe.
Mukohyama: That's my gut feeling, but it's still too difficult to attack the cosmological constant problem at this moment. My attitude now is to think about dark energy for a while.
Randall: Okay.
Mukohyama: Now, back to the LHC—it found the Higgs Boson, so people are looking for new physics beyond the Standard Model. What is the most exciting scenario from your point of view?
Randall: Well, of course I would love them to find this kind of gravitons. I do worry that the machine might have too low energy and eventually we want to have much higher energy machine, because just statistically it's not that likely that the new physics would be in the next machine, because we don't have that much room. We've already gone to 8 TeV and now we're only going to 13 or 14.
Mukohyama: Right.
Randall: It's a concern. But, of course it would be very exciting if something is in this machine and tells us what's going on, whatever it is. I mean, of course we hope that they'll find something.

Message to Young People in Japan

Mukohyama: Okay. I think this is your third or fourth visit to Japan, and your first visit to Kavli IPMU.
Randall: Yes.
Mukohyama: What is your impression about science in Japan?
Randall: There are some quite good people here. There are some quite good people who come to the States, even temporarily like you did. I hope to see it stays strong. In terms of my books, it's very nice that people were really interested at least in my first book, with the second one, not yet in the stores, just coming out; it was one of the most scientifically interested audiences, so I think that's very good.
Mukohyama: Scientifically I'm enjoying being here, especially at the Kavli IPMU. Here, people in different fields can communicate.
Randall: Is this the only Kavli IPMU building?
Mukohyama: Actually, we have the second building, a building shared with other institutes.
Randall: What are these other institutes?
Mukohyama: The next building is for the Institute for Cosmic Ray Research (ICRR), and the other building is for the Institute for Solid State Physics (ISSP).
Randall: Do you have any interactions with them?
Mukohyama: Sometimes some members attend seminars over there, and people also come here from there. Some people at ICRR are affiliated with Kavli IPMU. Also, we have some interactions with Physics Department which is located on the down town campus of the University of Tokyo.
Randall: Is it a bit far?
Mukohyama: Yes, a bit far, but I usually attend a seminar there on every Monday. Sometimes people come here, and sometimes we also have joint seminars among different institutes in the greater Tokyo area. I think there was something similar in Boston.
Randall: Yeah, there was. Not much any more. I think they are busy. There are so many seminars here. Do you hear seminars from Japanese people or foreigners?
Mukohyama: I think half and half. Maybe more people from abroad. And all seminars are given in English.
Randall: OK, very good.
Mukohyama: I remember at Harvard the every-day atmosphere was very stimulating, and we had a lot of seminars and so on.
Randall: Yeah, it's still lively. And here is it very interactive?
Mukohyama: Yeah.
Randall: Very good.
Mukohyama: Do you have any message for young people in Japan?
Randall: Just to be excited about science, to be happy about thinking for themselves, and of course not to the exclusion of understanding what other people are doing, but to get inspired by the amazing things that are happening. Also I hope things go well in Japan in the future.
Mukohyama: Thank you very much.
Randall: Okay, great. Thank you.