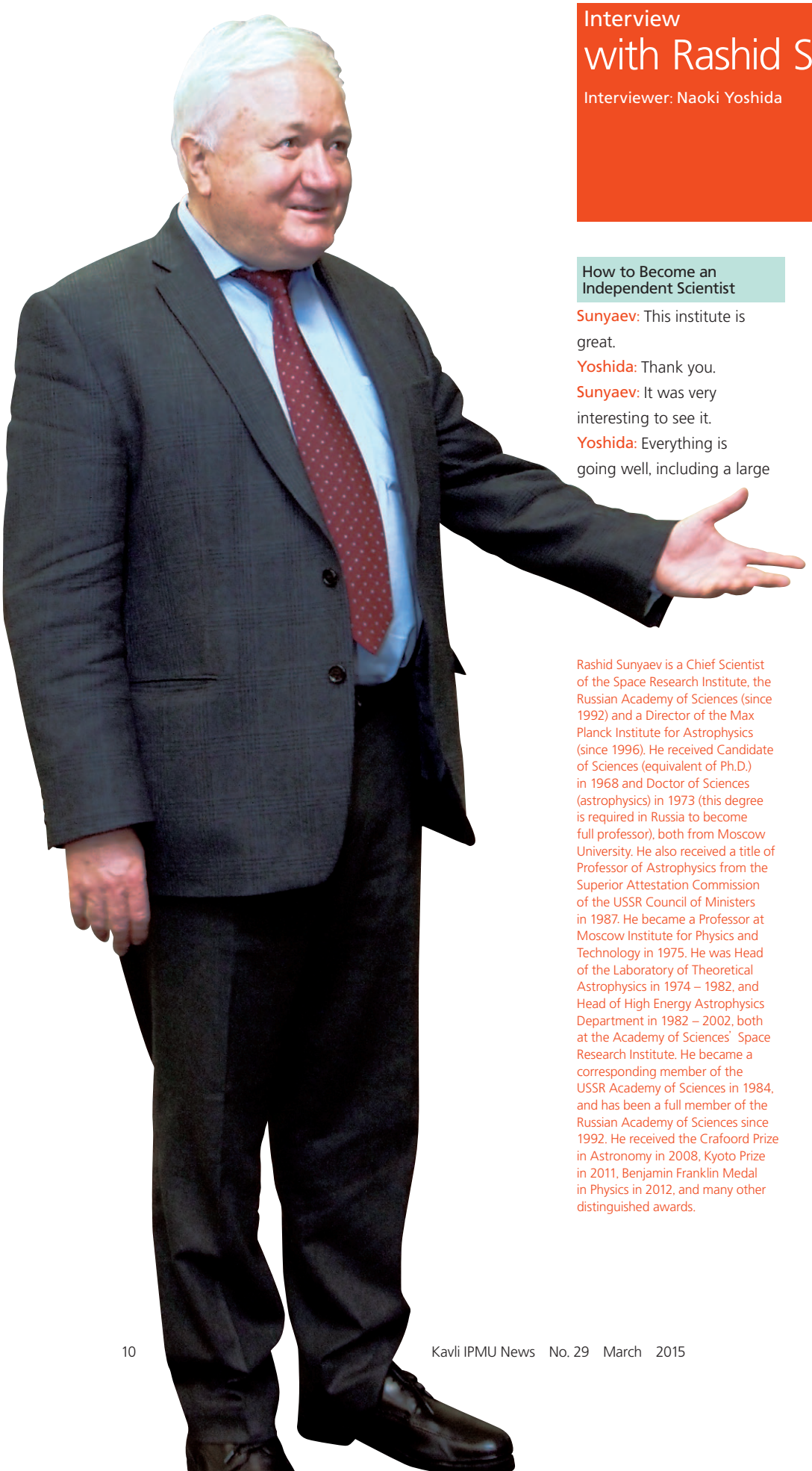
Interview

# with Rashid Sunyaev

Interviewer: Naoki Yoshida



## How to Become an Independent Scientist

**Sunyaev:** This institute is great.

**Yoshida:** Thank you.

**Sunyaev:** It was very interesting to see it.

**Yoshida:** Everything is going well, including a large astronomical survey, Subaru Hyper Suprime-Cam survey.

**Sunyaev:** Are you participating in it?

**Yoshida:** Yes, and we will get real data and real results very soon.

**Sunyaev:** Very good. I remember that you were working at the Max Planck Institute for Astrophysics.

**Yoshida:** As a student.

**Sunyaev:** You are now working at the Hongo campus. Are you working in the Department of Physics, not in this institute?

**Yoshida:** I spend 60% of my time at the Department, and 40% here.

**Sunyaev:** It's good sharing, okay.

**Yoshida:** Yes. I can conduct researches here at the Kavli IPMU. Okay, let me ask you about some questions today. The first question is about "independence." One particular thing I wanted to ask you is how to become an independent scientist. At what occasion did you first realize or become confident enough that you would be a good scientist?

**Sunyaev:** It's a very difficult question. I have never thought about it, but it's my

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impression that there was a moment when I recognized that I wished to become a scientist. It was a very important moment, because when you're a student, you don't know what you are interested in, but there is a great difference between the interest and the belief that you really should do this.

Yoshida: Yes.

Sunyaev: The second moment is when you're really starting to be confident that you're able to do this — Is this what you ask?

Yoshida: Yes, something like it.

Sunyaev: I was working with Yakov Zeldovich in his group at the Institute of Applied Mathematics, USSR Academy of Sciences. He was an extremely strong and bright scientist, very well recognized and very broad in his interests. He was sending me to different people to discuss science, recommending me to work with them also. Very rapidly I recognized that there are different grades of strong scientists. Zeldovich is a very high-grade scientist. There are people who are working in very narrow fields of science and who know very well those narrow fields. And then I recognized that I can be strong in some fields even on the level of those who were already full professors at that time, by just interacting with people to whom Zeldovich sent me to discuss things which we were doing, and trying to get their advice on the concrete very narrow subject. This was important. Then I started to work with some of these people, for example, these experimentalists. Experimentalists are great. I admire them because their life is much more difficult than life of theoreticians. Anyway, at some moment, you have a pleasure recognizing that you might be extremely useful for these experimentalists. You come to them and tell that it's possible to use their data for this and that, and try to interpret their data in the best way. Then you see that you can find your own niche

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and that in this niche, you're strong.

Yoshida: You found the value of yourself as…

Sunyaev: It's not only the value. I also understood the niche in which I was able to compete with many people rather successfully. I was very happy and Zeldovich also recognized this. Written together with Zeldovich, some of our papers became so successful. Sometimes, I am thinking why, and my impression is that one of the reasons was the following. At a very early stage I recognized that I'm interested in how to make the result of a theory observable. Many theoreticians around me were working only in theory, for theory, for further development of theory. I also found my niche to find what is possible to observe.

Yoshida: Interesting.

Sunyaev: This made my life much more interesting. I also recognized that it was possible to work not only with Zeldovich; I can be rather independent. This was also very useful. He was pleased when I was also working with other people, young people like a friend of mine Nikolay Shakura — we were working on the accretion onto the black holes. I had many strong students. I'm very grateful to them, not only because students are useful, but also because working with strong students is a pleasure. Students contribute a lot, but if students are strong, you're also learning a lot from them. They're not so busy and they learn much more rapidly than you. At some moment, they're starting to be competitive. I think it's very useful to work with young people. You should really do this.

Yoshida: I see. Was that roughly when you were 30 years old?

Sunyaev: I think it was close to the age of 25-27.

Yoshida: Okay. Then, did you become so self-confident?

Sunyaev: I think I did. I also tell you this. At the beginning when I started to work with Zeldovich, he was rather tough when I was not doing something very rapidly because of difficulties. He was showing that he has no time to speak with me and sometimes he was not recognizing me. For me, it was really very, very bad feeling.

Yoshida: I understand.

Sunyaev: But, when you were getting new results and coming to tell him, "I have new results," he immediately got ecstatic, telling "Okay, let's discuss." Then, I understood that maybe his behavior was just a way to demonstrate his intention to make me work more hard.

Yoshida: To prompt or motivate you.

Sunyaev: Yes, motivating, but this was a rather tough way of motivating. At some moment, I also recognized that he was also happy to work with me. This was a great feeling. He was interested in you; he was so strong and so well known. This also showed you that you are not absolutely the last person in the world. This was good.

Yoshida: Okay, I think your story is very encouraging to young people and that's why I wanted to ask this question to you.

## Relation between a Supervisor and a Student

Sunyaev: It's important. But, you know, life is changing. The behavior of people is changing and the relation between a supervisor and a student is now very different from that in the time when I started. Also, the American way of interactions or Anglo Saxon way of interactions between professors and students is very different from that which was accepted in Russia and Soviet Union when I was young.

Yoshida: In Russia and Soviet Union, I suppose it was more like a mixture, more like a family style and also like in a more hierarchical, logical style.

Sunyaev: In Soviet Union, it was strongly hierarchical. It was the same in Germany. Usually people were staying in the same group if they were successful, practically whole their scientific life. This was completely different from the Anglo Saxon way. In America, it's important to move from place to place, and to learn more. But in Russia, in many groups, their chief was doing something like a top advisor, and then the second person made a first correction to his theory and so on. Finally, it became the "seventh approximation." From one side, people were able to go very deep. From another side, people were slow in progress, because they were unable to become broad — the conditions to become broader were much more difficult.

Yoshida: That's very interesting, because many younger people struggle with becoming independent at some point. As a student, there is some learning without much thinking. But, eventually, they want to become very independent and this happens in a variety of ways depending on the person.

Sunyaev: Yes, it depends on personality and character. I completely agree with you. A lot depends also on the interests. Zeldovich had the feeling of what is interesting for a person. When I first came to him, he asked "What are you interested in?" At that time, I was rather good in mathematics, but I told him that I liked physical processes. It was interesting for me to learn physical processes working in, for example, gas chambers and other detectors of elementary particles. Then he was trying to direct me to where it was necessary to investigate elementary physical processes. This was interesting for me and this became very useful part of my work.

## Russian System of Finding Excellent Young Talent

Yoshida: Okay, interesting. Now, the second question is somewhat related. I'm always impressed by the Russian or former Soviet Union's systems in many ways, and one thing I want to know is the following. There must be some nationwide search process for excellent young talent. You're from Tashkent, but somehow you went to Moscow. There must be some centralization system, too. How do they work in Russia?

Sunyaev: I can tell you that system of Soviet Union. It was very strongly centralized, but there are many countries with great centralization. For example, in France every young person understands that for his career, it's important to go to Paris at some stage.

Yoshida: But, in Soviet Union, I think even at the high school level, it seems to have been working….

Sunyaev: Tashkent had universities, but everybody knew that the level of these universities was lower than the universities in Moscow or Leningrad at that time — but high schools were rather good.

Yoshida: High school teachers were also very good?

Sunyaev: High school teachers were good. Schools were good. But the best students, I don't know how, knew that it's good to go to Moscow.

Yoshida: Oh, you don't know how. That's something I wanted to know.

Sunyaev: We heard that if you wish to do, for example, science or to learn most modern things, it's better to go to Moscow. We knew that there is continuous flow of the strongest people there. For example, if a professor in Tashkent was really very good, at some moment he was invited to go to Moscow. If you had a really good ballet star at your theater, then Moscow was inviting this ballet star. Therefore, people were going up. For me, extremely important was an additional episode. When I was 17, one day I was invited to participate — just without any preparation — in the Olympiad. Do you know what it is?

Yoshida: Yes.

Sunyaev: I was invited to participate in the Mathematical Olympiad of Central Asia and Kazakhstan. These were five Soviet Republics — now, independent states — Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan, and Kazakhstan. Altogether, there were maybe 50 million people at that time. People from different, best schools in these republics were sent to Tashkent, and several high school students from Tashkent were also invited to participate in this competition in mathematics. I don't know how, but I won, and then I was sent to Moscow to participate in the Olympiad of the whole Soviet Union. I lived in the dormitory of Moscow University and I was very impressed: according to my level of understanding, it was a great palace. It was an enormously big building and very nice. They had theaters inside. I was going to theaters. They had very good canteens, restaurants for students. Everything was excellent. A lot of young people. For me, this was very impressive.

I was living in the room with a mathematician student. This student told me that there was another school (Moscow Institute of Physics and Technology). It was not so attractive a place, but students there were even better. In that school, entrance exams were held 1 month earlier. Therefore, I decided to go to that school to take my exams. We had competition of 11.5 people per place. I don't know how, but I passed. I was accepted. Life was not very simple. After I entered Moscow Institute of Physics and Technology, five people including me lived in one room and everything was different. And there was a very pressing system that you should learn, learn, and learn there, and very tough exams. But it was okay. I'm very grateful to that school, because professors were really brilliant. People who were teaching us were very good.

Yoshida: I guess it was also similar for your friends, perhaps, one maybe from Vladivostok, the other from St. Petersburg and so on. They're not only from Moscow, but from all over…

Sunyaev: Soviet Union.

Yoshida: That is impressive.

## Best Students Come and Learn in the Best Universities

Sunyaev: You know when Soviet Union was destroyed and we got a lot of independent states, then there were attempts to make best schools of Russia closed for people coming from different republics which were former part of Soviet Union. At that time, I had conversation with my friends in Russian Academy, and we agreed to write a letter to the top people in the country and to the Ministry of Education. It said that if they will consider the members of the Russian Academy of Sciences, they will discover that these people are not only people from Moscow. They are coming from the whole country, because talents are distributed uniformly. These talents came to Moscow and learned in Moscow in some way, and they came to belong to the academy, and they became best professors of Moscow University and so on. If we do not permit people from half of the country, now outside of Russia, to study in Moscow, then we just lose them. It's better for Russia if these people will be accepted and will get this ability to learn. I don't know how it worked, but many schools

now are permitted to accept best students from whole territory of former Soviet Union without payment.
Yoshida: Without payment?
Sunyaev: They're not paying tuition, because people in the majority of these republics are poor because they do not have oil deposits. For example, Tashkent was a very rich city in the times of Soviet Union, but now it's poor in comparison with Moscow.
Yoshida: I see.
Sunyaev: Everything is simple. Best students can come and learn in the best universities, but obviously, they should compete for their entrance. If they get excellent results, then it's not necessary for them to pay tuition. This is very important. But, there are quotas. I don't know exactly, but every year rules are changing. For example, if you wish to enter schools of economy and the like, you should pay, but if you wish to enter schools of science such as physics, it's possible not to pay as far as you are excellent.
Yoshida: I see. Actually, is physics or basic science still a top choice or popular among young students in Russia?
Sunyaev: No. Unfortunately, it has completely changed.
Yoshida: Really?
Sunyaev: Many young people wish to be in the positions where it's easier to get higher salaries and so on. But it's the same as the trend in the whole world. But in my time, physics or basic science was enormously popular and most young people were trying to enter schools of this sort. I think maybe the same was true in Japan.
Yoshida: Similarly, yes. We still have popularity or interest of high school students in physics or basic science, but obviously, the overall interest is now decreasing. Well, there are lots of other interesting stuffs.
Sunyaev: But a lot of people understand, for example, that biology or life sciences have great future, and young people are going there.
Yoshida: Yes.
Sunyaev: There was a conference in Tallinn devoted to 100th birthday of Zeldovich, and I was attending it. There were several well-known people there. They were asked what they thought about the education system, and somebody asked "Would you recommend your children to go to astronomy?" Everybody told what profession their children had. Nobody of children of these well-known astronomers was doing astronomy. One or two were doing physics, but the majority of them were doing life sciences and economics.
Yoshida: Okay. I usually tell my students that astronomy will be probably very good at least for the next 20 years.
Sunyaev: I have no doubt that for the next 25 years astronomy will be blooming, because we expect not only great ideas, but also great instruments which leading countries are building.
Yoshida: Exactly.
Sunyaev: These instruments will give enormous amount of information, and it will be necessary to have strong people to process the data and to interpret them to do great science.
Yoshida: Yes, exactly. I really think astronomy would produce a lot of young talent.
Sunyaev: Yes, but I think life sciences certainly will be doing very well also.
Yoshida: There are many things to work in life sciences, but I still like astronomy.
Sunyaev: Astronomy is very good. I agree with you, but astronomy is still much smaller than physics, and physics now is much smaller than life sciences. Do you agree?

## Computers in Basic Science

Yoshida: Okay, that is true. That's very interesting. Now, the third topic I want to talk with you is about computers, especially using computers in basic science. Here, I still have a sort of mixed feelings. I appreciate the powerfulness or usefulness of the computers, whereas still I'm not very sure whether or not computers can play an important role to reach a true or fundamental understanding. As you know I use computer simulation as my primary research tool, and I'm always asking if this kind of activity or research can really reach a very fundamental thing.
Sunyaev: I myself think that really computers are a great addition, because I wrote majority of my papers using slide rules. Then, I saw how computers were becoming more and more useful part of our life.
Yoshida: It is.
Sunyaev: Numerical astrophysics and cosmology uses the biggest supercomputers, and is one of the fastest developing branches of our science. However, I wish to start with the statement that life today without computers is really impossible. The first thing is that they made our life much simpler. When I was young in Russia, for example, we had, I do not know the exact number, but something like a million of secretaries who were typing whole day.
Yoshida: I see.
Sunyaev: Now, it's a very rare case for a secretary to type. Everybody is typing on computers himself or herself — very fast and easy work. This is just an example of the changes that an enormous number of people were replaced by computers. Second, it was rather difficult at that time to make the computations, and we had to spend a lot of time to solve even simple problems using approximate methods or using tables and special functions. Computers did this really very easily. Programs like Mathematica or many others just made use of simple mathematics much easier. It's not necessary to sit

whole day to compute with a slide rule. But I understand that this is one side which is very useful and very important, and computers will become more and more useful. At some stage, it will be possible to dictate a paper. Computers can publish and edit it, and so on. Computers can do a lot, and this will help enormously. But, then, there is a question. Can computers learn absolutely fundamental things? There are two possibilities. The first possibility is to make very deep mathematics. I think for that we still need people. I don't know for how long.

Yoshida: I just remembered, many of these great Russian or Soviet scientists, like you, Aleksandr Kompaneets, and Leonid Sedov.

Sunyaev: Academician Sedov and Prof. Kompaneets found great analytical solutions and derived now well-known equations. These solutions and equations are always useful and often necessary.

Yoshida: I think you know that was actually…

Sunyaev: In this field, I don't think that computers will replace people in this direction very soon. People are still very good in such things and also a lot depends on the intuition. It is one case where I think our brains possibly will compete rather long with the most powerful computers, but there is a chance.

Yoshida: Maybe, yes.

Sunyaev: Then, there are simulations in the complicated problems where we understand a lot, but we cannot estimate numerically all consequences. And here obviously, computers are just unavoidable, and they will give us a lot. Progress without simulations, without these huge, computational resources will be really much slower. Therefore, I think that it is great that they are there. But, again, analytical solutions are extremely useful, because if you have the exact solution for something, you can always check if everything is correct. This is also a very important and useful thing. But, I think that it's already impossible to return to science without great computational facilities.

Yoshida: I always ask this question to myself and to students so that we keep a sort of balance between…

Sunyaev: Yes, we should keep balance, but I think that computers have changed our life. Just for normal life, already calculators were useful. But with what we have now, we can solve a lot of simple problems. What is simple? Now you can solve any differential equation which was enormously difficult 200 years ago. It's not great science today. It's just useful.

Yoshida: It is.

Sunyaev: I think it's important not to forget this part of classical mathematics, which is useful.

Yoshida: Quite an interesting viewpoint. I actually asked everything that I wanted to ask, I think. Do you have any questions or suggestions?

Sunyaev: No, I'm just grateful, because I'm first time at this institute, and it is a great pleasure to see a really international institute here in Japan, where I had conversation with several young people from Germany, from Australia, from America, and from Russia. Everybody looks happy and everybody is saying that your top people have created here the atmosphere where people are happy to work, where it is interesting for them, and it's great. And you have these visitor programs. It seems that they are very good, because you are inviting really the best young people. It's a mistake to invite only old people. It's important to invite people who are actively working now, and it seems that this is the case here.

Yoshida: Thank you very much. I appreciate your compliments.

Sunyaev: No, it's not compliment. It seems that it's true and I think that this institute should have a great future. In Russia, we are till now unable to create similar atmosphere; I'm very unhappy for that. There have been attempts, but in fundamental science, there are practically no places, internationally, similarly open for discussions, except, possibly, the Euler International Mathematical Institute in Saint Petersburg.

Yoshida: I hope you keep your attention to our institute, and also give us many suggestions in the future. We will really appreciate it.

Sunyaev: Thank you and it's a pleasure.

Yoshida: Thank you very much.