IPMU Interview

with astronaut Takao Doi

Interviewer: Hitoshi Murayama

How does it feel to catch hold of a 1.3 ton satellite?

Murayama: Mr. Doi, I was very impressed when you performed a spacewalk and grabbed the Spartan satellite with your hands. Didn't you feel any fear when you go out of the spacecraft like that?

Doi: We feel no fear because we train repeatedly on the ground for EVAs (extravehicular activities). However, while we are working on EVAs, we are exposing ourselves to danger, so we must pay great attention even to things which are not directly related to the assigned tasks. EVAs demand great concentration. They are also physically demanding.

Murayama: Really! To me, your spacewalk looked very much like a stunt. What did you feel when you actually grabbed the satellite with your hands?

Doi: It felt very light. The Spartan satellite weighs approximately 1.3 tons, about the same as a compact car. It was approaching our space shuttle at a speed of about 5cm per second. Due to this inertia, I felt a heavy weight the moment we grabbed it, but after that, while rotating the satellite and adjusting its position, it felt very light.

Murayama: That's quite natural according to the laws of physics, but still it's amazing, isn't it?

Doi: It certainly was amazing. However, the inertia meant there was a danger of possibly losing control of the satellite if we moved it too fast. We were aware of that, of course. Astronaut Scott and I practiced rotating or moving the satellite in the same direction and with the same speed.

Takao Doi joined the National Space Development Agency (NASDA) of Japan - now the Japan Aerospace Exploration Agency (JAXA) - in 1985 as a payload specialist and has been working in the Japanese manned space program since then. In 1996 NASA and NASDA selected him as a mission specialist. He flew on the Space Shuttle Columbia in 1997 and is the first Japanese astronaut to perform an EVA (Extravehicular Activity, or spacewalk). In March 2008 he flew on the Space Shuttle Endeavour, which delivered the Japanese Experiment Logistics Module, Kibo Laboratory to the International Space Station. He received a Doctorate in Aerospace Engineering from the University of Tokyo in 1983, and a Doctorate in Astronomy from Rice University in 2004.

A fascination with space that only grows with visiting it

Murayama: I see. Now I'd like

to ask what motivated you to become an astronaut.

Doi: I was interested in nature from the time I was an elementary school child. I was a boy who loved playing outdoors, doing things like fishing and collecting insects. I was introduced to the stars after entering junior high school. First I tried observing sunspots, which was the easiest introduction. The landing of Apollo on the moon, which took place when I was in the third year of junior high school, strongly impressed me. I remember very well the scene of Captain Armstrong walking on the moon. Probably I became interested in the universe during this period.

Murayama: Did you continue your sky observations after junior high school?

Doi: Yes. Starting with the sun, I gradually moved on to the night sky. Taking photos of the sky was becoming popular then, and that inspired me to also take nice photos for myself. I was camping out at many palces and having a good time.

Murayama: I understand you also discovered supernovae.

Doi: That came much later. I started by observing sunspots, moved on to observing stars with the naked eye, and then continued on with night-sky photography. Eventually, however, I became unsatisfied and was eager to know more about the universe. I wanted to try different things, and started to look for supernovae. This occurred much later, when I was in my late thirties.

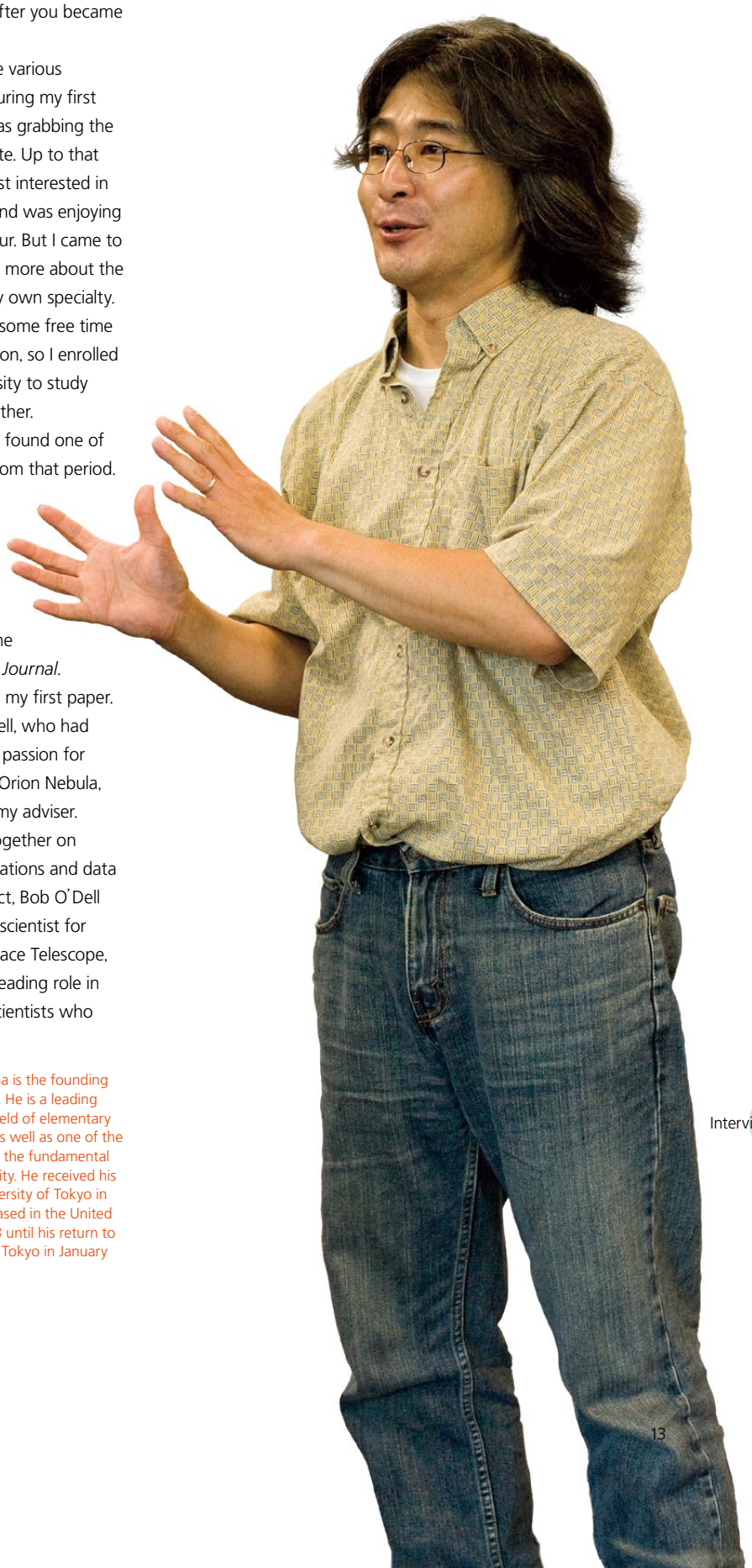
Murayama: I understand that you earned your Ph.D. in astrophysics after you became an astronaut.

Doi: I did have various experiences during my first mission, such as grabbing the Spartan satellite. Up to that point, I was just interested in the universe and was enjoying it as an amateur. But I came to want to know more about the universe as my own specialty. I could afford some free time after the mission, so I enrolled at Rice University to study astronomy further.

Murayama: I found one of your papers from that period. It was about calibration of a filter for the Hubble Space Telescope, published in the *Astrophysical Journal*.

Doi: That was my first paper. Professor O'Dell, who had a tremendous passion for analyzing the Orion Nebula, agreed to be my adviser. We worked together on several observations and data analyses. In fact, Bob O'Dell was a project scientist for the Hubble Space Telescope, and played a leading role in the team of scientists who

Hitoshi Murayama is the founding director of IPMU. He is a leading physicist in the field of elementary particle theory, as well as one of the young leaders of the fundamental science community. He received his Ph.D. at the University of Tokyo in 1991, and was based in the United States from 1993 until his return to the University of Tokyo in January 2008.



constructed the Hubble Space Telescope. Under his guidance, I worked on calibrating the filter, with which there were some problems at that time.

Murayama: What did you work on after that?

Doi: I worked on the Orion Nebula. A large number of new stars are being born in this nebula and jets are emerging from the region of new-born stars. Shock waves are generated as a result of the interaction between the jets and the molecular cloud. These shock waves have very complicated structures that are related to both the origin and the structure of the Orion Nebula. I worked on observing and analyzing these shock waves with Bob O'Dell. These shock waves move as time passes. If very precise images of the shock waves are taken, we can know the change in their locations after 5 years or 10 years, and that allows us to determine their velocities. Using Hubble Space Telescope images, we were able to determine their velocities with ten times better precision than the ground-based observations.

Murayama: I suppose you benefited a great deal from the knowledge of fluid dynamics calculations you gained through aerospace engineering.

Doi: Yes, I did. The shock waves are generated by the interactions of the jets with the surrounding gas. The knowledge of fluid dynamics I acquired when I was at university was very useful in analyzing the structure of the shock waves.

Dark matter, interesting because we don't understand it

Murayama: I see. Regarding your supernova observations, recently people have been using supernovae to measure the expansion of the universe, and the amount of dark energy is now known quantitatively. In what aspects of supernovae are you interested?

Doi: I was able to observe supernovae that appeared in relatively nearby galaxies such as those in the Virgo Cluster, so unfortunately they had nothing to do with the expansion of the universe. What I was most interested in is the fact that heavy elements produced inside stars spread through space due to the explosion of supernovae, and these heavy elements are the necessary ingredients for creating planets and life. This whole process is miraculously well organized. It gave me a sense of the mystery of the universe. This motivated me to look for supernovae.

Murayama: Does this mean that your interest in the universe is strongly related to your curiosity about the cycles of birth and death of stars, something like the metempsychosis of nature?

Doi: I guess so. When I first came to be interested in the universe, I wanted to go to the moon, Mars, and other planets and to confirm with my own eyes that they really exist, and to look for life if it is there. My interest then gradually shifted to the evolution and structure of the universe that created life.

Murayama: I think tremendous progress is being made in this area nowadays. We now know how the universe evolved to its present state.

Doi: Recent astronomical research has told us about things like dark matter and dark energy, and has also told us that the amount of visible matter is only 4%. It sounds very mysterious to me. It's really difficult for me to imagine such a world. Do experts have a good idea about where the dark energy comes from and what it is?

Murayama: We have absolutely no answer yet.

Doi: That's very interesting.

Murayama: Of course, we have formulated many scenarios, but we have not reached a convincing answer yet.

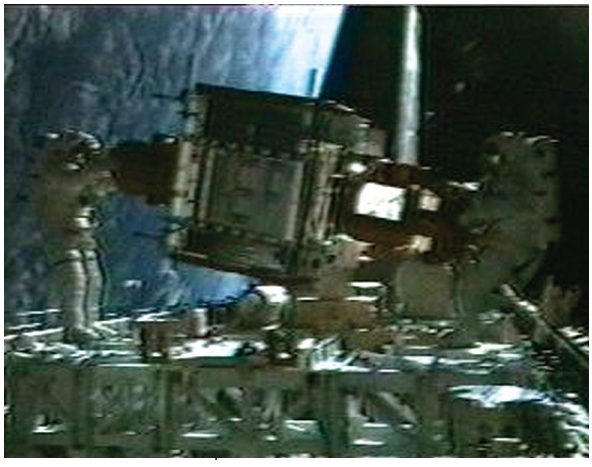
Doi: It's said that the percentage of dark matter is 23%. If so, am I correct in saying that dark matter exists in our planet system?

Murayama: Yes, that is correct.

Doi: We launch rockets, but we ignore the existence of dark matter when we calculate their orbits. I think this is somewhat contradictory because the dark matter must exert gravity. How do you explain this?

Murayama: The effects of dark matter can be safely neglected in the case of a rocket being launched from the Earth. However, the solar system, including our Earth, is circulating around the Milky Way Galaxy at an extremely high speed of 220km per second, which is only possible because dark matter in the Milky Way Galaxy is holding the solar system together, so actually there must be plenty of it around us.

Doi: It must exist, but it



Left: Mission specialist astronauts Takao Doi (right) and Winston E. Scott (left) await the approach of the Spartan satellite to the Space Shuttle Columbia. (Courtesy of NASA/JAXA)
Right: The two mission specialists successfully grab the Spartan satellite manually. Takao Doi (right) and Winston E. Scott (left). (Courtesy of NASA/JAXA) (Images captured from video)

is invisible. That's quite a mystery!

Murayama: Dark matter freely penetrates our bodies; it easily penetrates rocks to reach underground, and on rare occasions it may collide with a detector which is located there. IPMU is planning such an experiment. If we are lucky, we may see 2 or 3 such collisions per year. We are hoping to confirm the presence of dark matter in this way.

Doi: Do you think the best guess is that they are some type of matter or elementary particle which is as yet unknown to us?

Murayama: Yes, that is what most of us are guessing. Of course, we don't know for sure yet.

Doi: I feel that a new view of the world has emerged suddenly. It's fascinating, but at the same time, it's very shocking to know that the astronomy we have developed so far has been looking at only 4% of the universe's constituents. Well, perhaps we should say it's "interesting" rather than "shocking".

Murayama: It's extremely interesting. I really hope to pin this down.

Doi: Well, good luck to you.

Hopefully children will learn about the nature around them before they study space

Murayama: Scientific research using the Japanese "Kibo" laboratory in the Space Station will soon start. What do you think the most important direction will be for this scientific research in space?

Doi: Well, let me see. One thing is the space experiments. With the completion of the Kibo laboratory, which can provide Japanese scientists with good data on the characteristics of outer space in a short time and economical way, we will soon see good achievements in life science, material experiments, and various experiments on physical phenomena in space. Japanese scientists have been conducting space experiments for nearly 20 years, but they were forced to take too long a time because of the use of Space Shuttle missions. Another thing is related to unique features of the Kibo laboratory, the Exposed Facility (EF) and the Experiment Logistics Module-Exposed Section (ELM-ES). EF provides a multipurpose platform where science experiments can be launched and conducted in an exposed environment. We can use an optical telescope and an X-ray telescope, as well as an instrument that allow constant monitoring of the Earth's ozone layer. We can put a telescope like the Hubble Space Telescope in a manned facility. The strongest feature of the EF and ELM-ES is that they enable frequent and easy access for replacing and manipulating observational instruments.

Murayama: How do you manage your life both as an astronaut and as a scientist undertaking your own research?

Doi: Keeping up both roles is difficult. Astronauts are assigned to a specific mission about one to one and a half years in advance. Once assigned, we must devote ourselves to the mission and we must give up working on our own research completely. Even when we are not assigned to a specific mission, we must go through regular training. We also have some NASA-related work, so we can only do research in our spare time. I think it is difficult to manage both tasks. I was very lucky because after the first mission NASA allowed me to have one day per week free for studying at university.

Murayama: Do you mean that you got a Ph.D. degree with only one day's study per week?

Doi: Yes, but I worked every night at home until late doing data analysis.

Murayama: That is very impressive. By the way, as scientists we are trying to attract young people to science in various ways. Please tell me your thoughts about how we can attract young people to science and, in particular, to the study of the universe?

Doi: Based on my experience when I became interested in science as a young boy, I think it is not advisable to start initially with subjects that are too difficult, as young people may rebel against, and depart from, science. It is important to go forward step by step. For example, elementary school children may not have enough money to buy a telescope even if we talk about the universe. Becoming familiar with nature in an easier way, like collecting insects, may be more appropriate for them.

Murayama: Certainly I didn't have any money to buy a telescope when I was a kid.

Doi: In my case, I was able to buy a telescope with my own money only after entering junior high school. I think this kind of step by step approach is better. It would be out of balance if kids knew only about the universe. They must first learn about the Earth, nature, and life. They must learn from hands-on experience. Learning from just books is inadequate. They can expand their world to the space around the Earth or the Big Bang as they go to junior high school and high school. I hope we can provide good books and learning materials as they proceed step by step. The other day, I visited the National Astronomical Observatory and, for the first time, saw a three dimensional movie about the solar system and clusters of galaxies in the universe. We now have places such as this where we can have exciting experiences of the universe.

Murayama: Yes, that movie is fantastic.

Doi: I think it would be great if people could see displays like that in planetariums and other places.

Murayama: I agree. Thank you very much.